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**Son**

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(54) **ELECTRIC BICYCLE DRIVING APPARATUS**

(71) Applicant: **MANDO CORPORATION**, Pyeongtaek-si (KR)

(72) Inventor: **Hong Youp Son**, Suwon-si (KR)

(73) Assignee: **MANDO CORPORATION**, Pyeongtaek-si, Gyeonggi-do (KR)

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(22) Filed: **Nov. 20, 2012**

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(51) **Int. Cl.**

***H02P 27/00*** (2006.01)
***H02P 1/46*** (2006.01)
***H02P 7/06*** (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC .. ***H02P 7/06*** (2013.01); ***B62M 6/45*** (2013.01); ***B60L 11/007*** (2013.01); ***B60L 15/20*** (2013.01); ***B60L 15/2045*** (2013.01); *Y02T 10/7283* (2013.01)

(58) **Field of Classification Search**

CPC ... H02P 21/0089; H02P 7/292; H02P 21/146; H02P 6/06; H02P 7/06

USPC ................. 318/494, 126, 119, 373, 369, 701; 701/22; 438/104, 151, 3, 460, 655, 10, 438/197; 388/809–815, 816–827, 828–830, 388/844, 853

See application file for complete search history.

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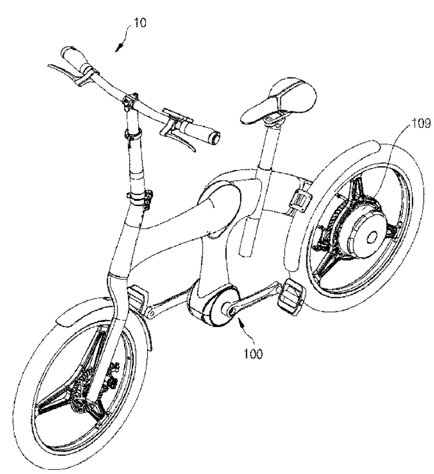
*Primary Examiner* — Bentsu Ro
*Assistant Examiner* — Zemenay Truneh
(74) *Attorney, Agent, or Firm* — McDermott Will & Emery LLP

(57) **ABSTRACT**

An electric bicycle driving apparatus is disclosed. The apparatus includes a speed change mode operator to output a first speed change mode signal or second speed change mode signal, a controller to receive the first speed change mode signal or second speed change mode signal and output a first control signal corresponding to the first speed change mode signal or a second control signal corresponding to the second speed change mode signal, a motor driver to, when the first speed change mode signal is output, receive the first control signal and output a first motor driving signal to drive a motor in a first speed change mode, and, when the second speed change mode signal is output, receive the second control signal and output a second motor driving signal to drive the motor in a second speed change mode, and a relay to selectively receive a relay switching enable signal.

**7 Claims, 32 Drawing Sheets**



(51) **Int. Cl.**

| | |
|---|---|
| ***B62M 6/45*** | (2010.01) |
| ***B60L 11/00*** | (2006.01) |
| ***B60L 15/20*** | (2006.01) |

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| JP | 2001-008480 | * 12/2001 | ................ | H02P 6/06 |
| JP | 2001008480 | * 12/2001 | ................ | H02P 6/06 |

OTHER PUBLICATIONS

Bork et al, Speed Match/Lost Grating Detection Apparatus, Feb. 1, 1981; IP.com Electronic Publication ; Original Disclosure Information: TDB 02-81 p. 4011-4016.*

* cited by examiner

FIG. 1

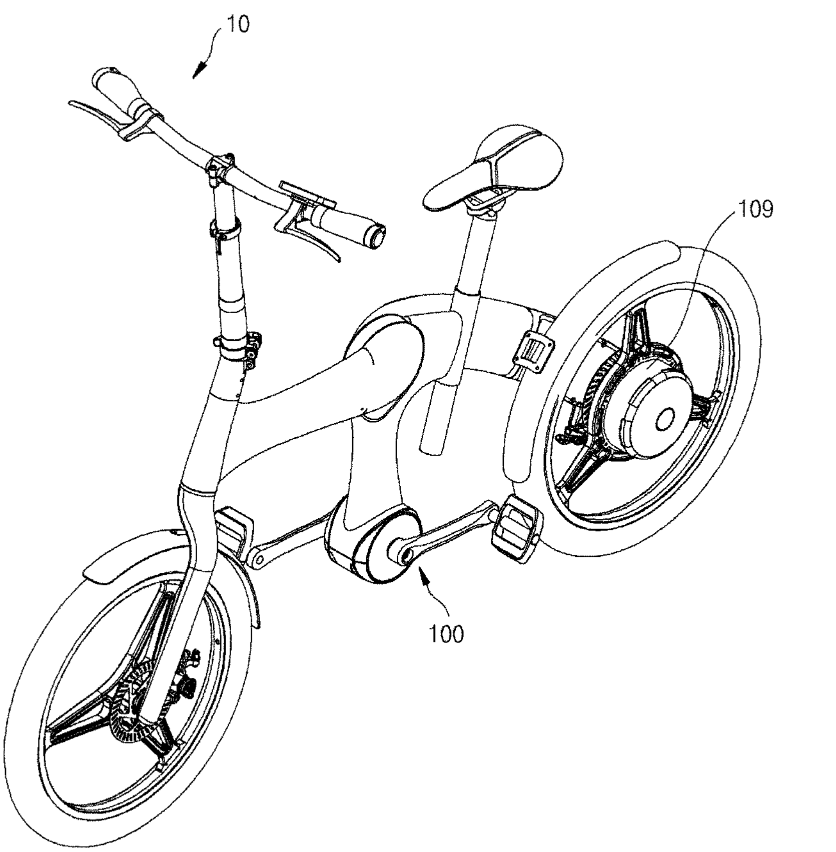


FIG. 2

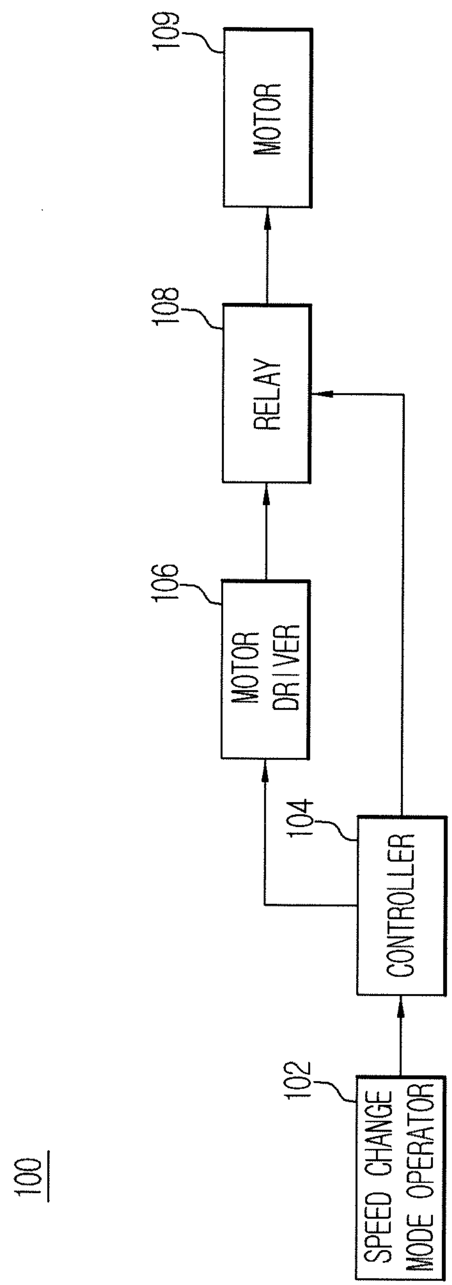

100
SPEED CHANGE MODE OPERATOR
102
CONTROLLER
104
MOTOR DRIVER
106
RELAY
108
MOTOR
109

FIG. 3

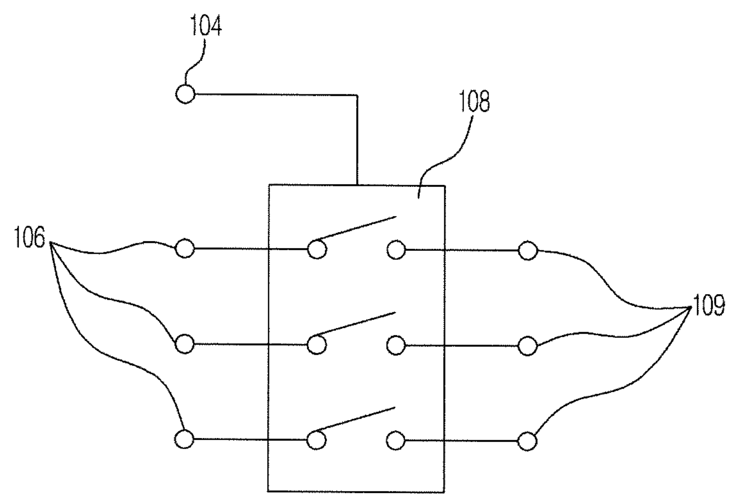


FIG. 4

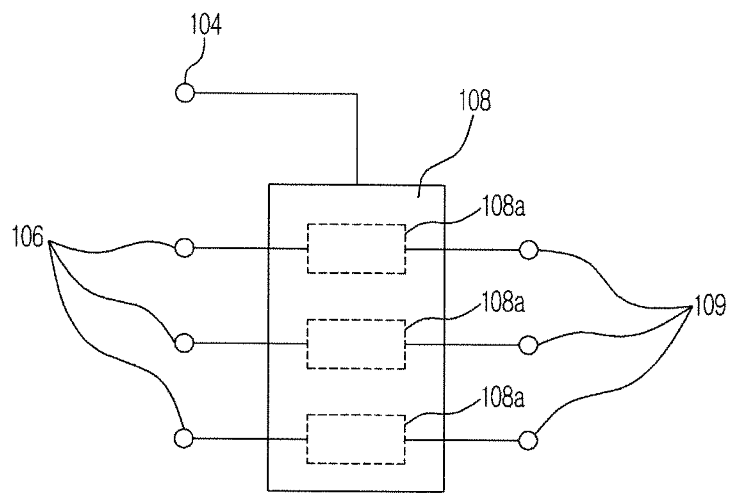


FIG. 5

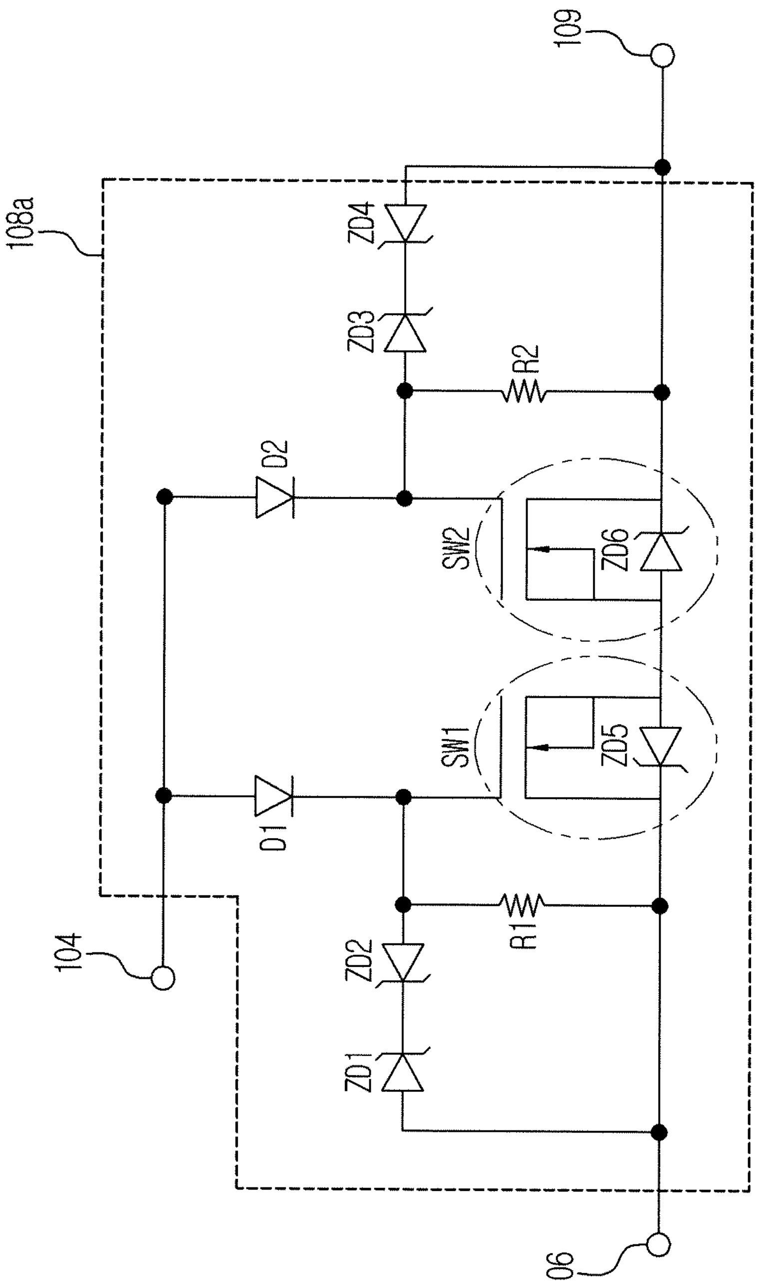


FIG. 6

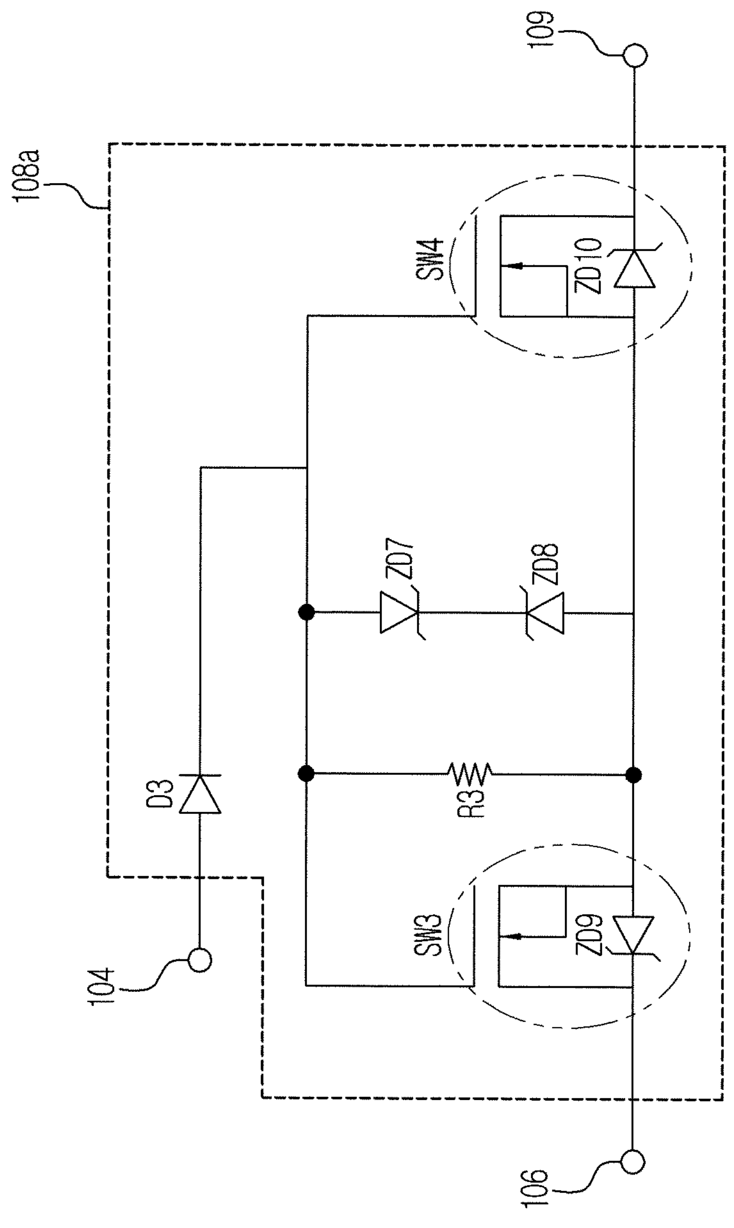


FIG. 7

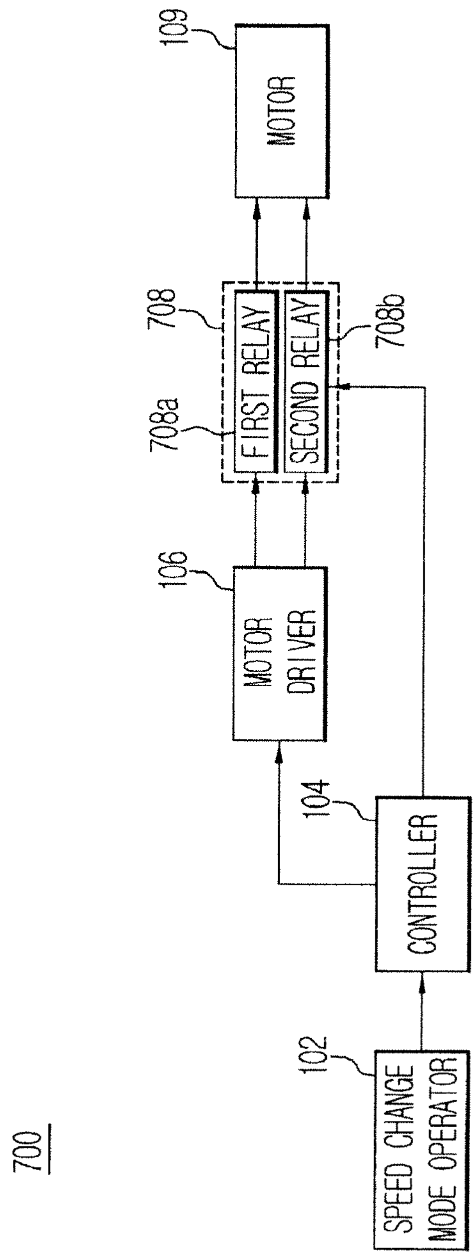

700
SPEED CHANGE MODE OPERATOR
102
CONTROLLER
104
MOTOR DRIVER
106
FIRST RELAY
708a
SECOND RELAY
708b
708
MOTOR
109

FIG. 8

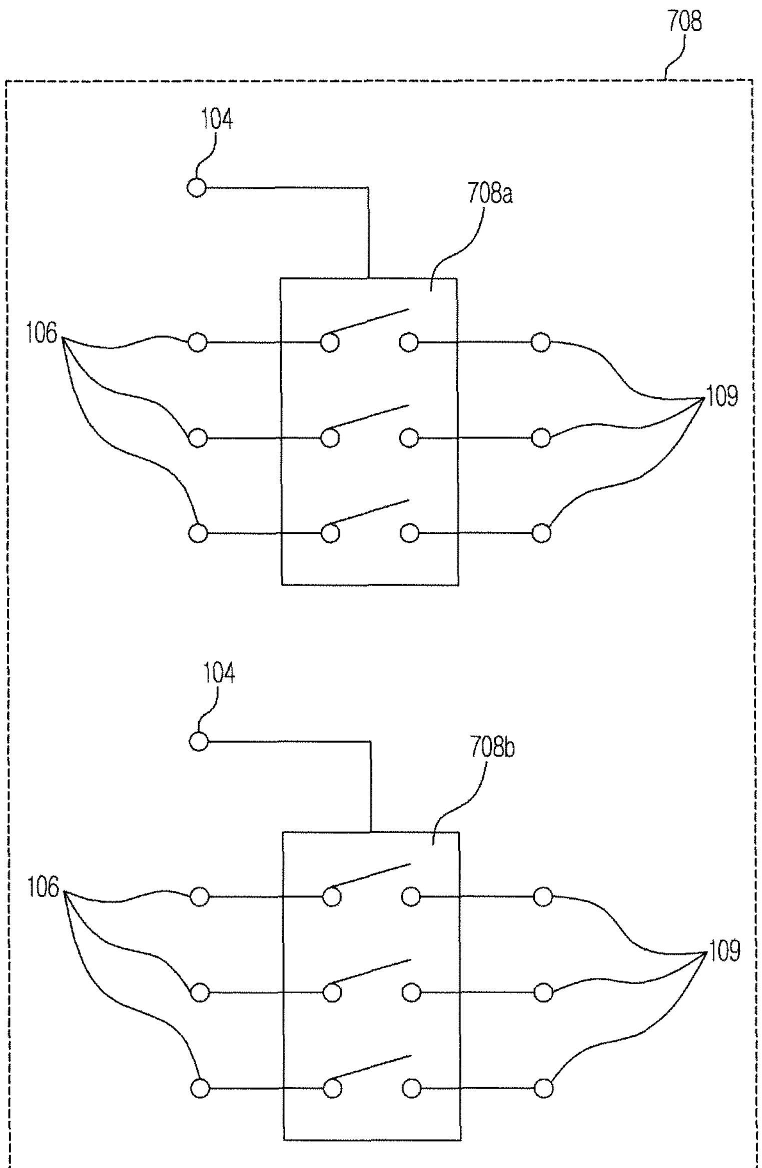


FIG. 9

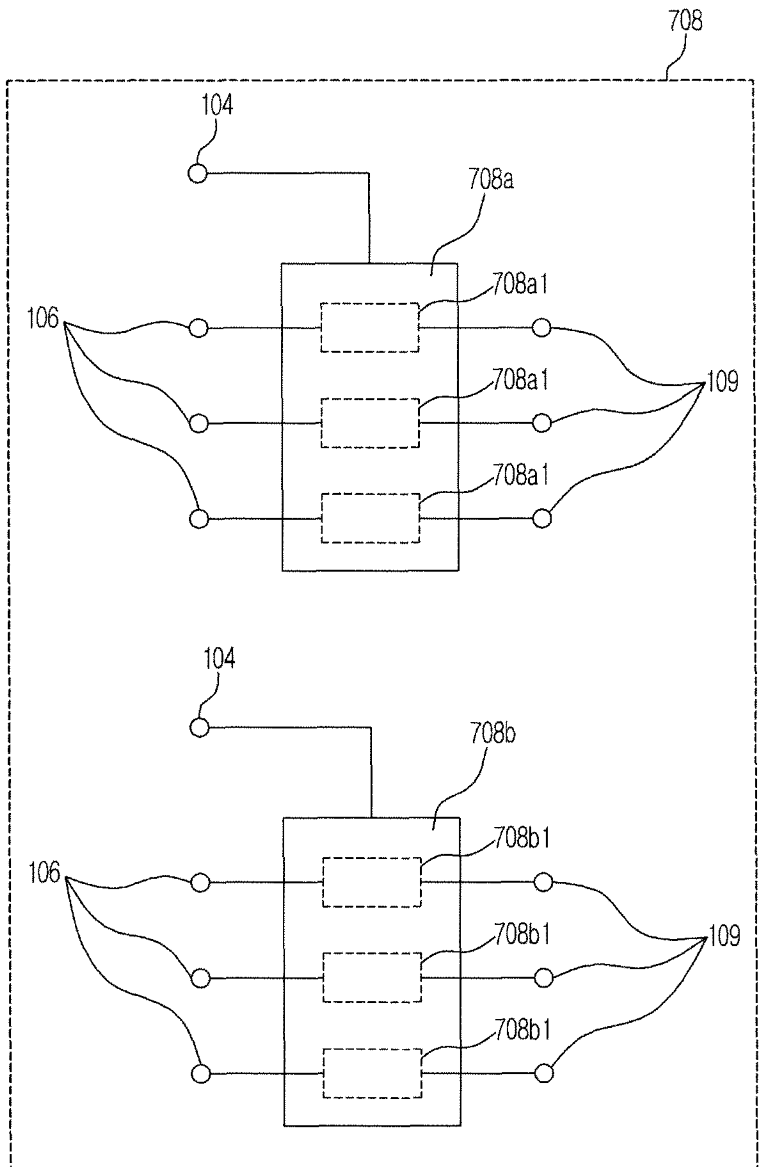

708
104
708a
708a1
106
708a1
109
708a1
104
708b
708b1
106
708b1
109
708b1

FIG. 10

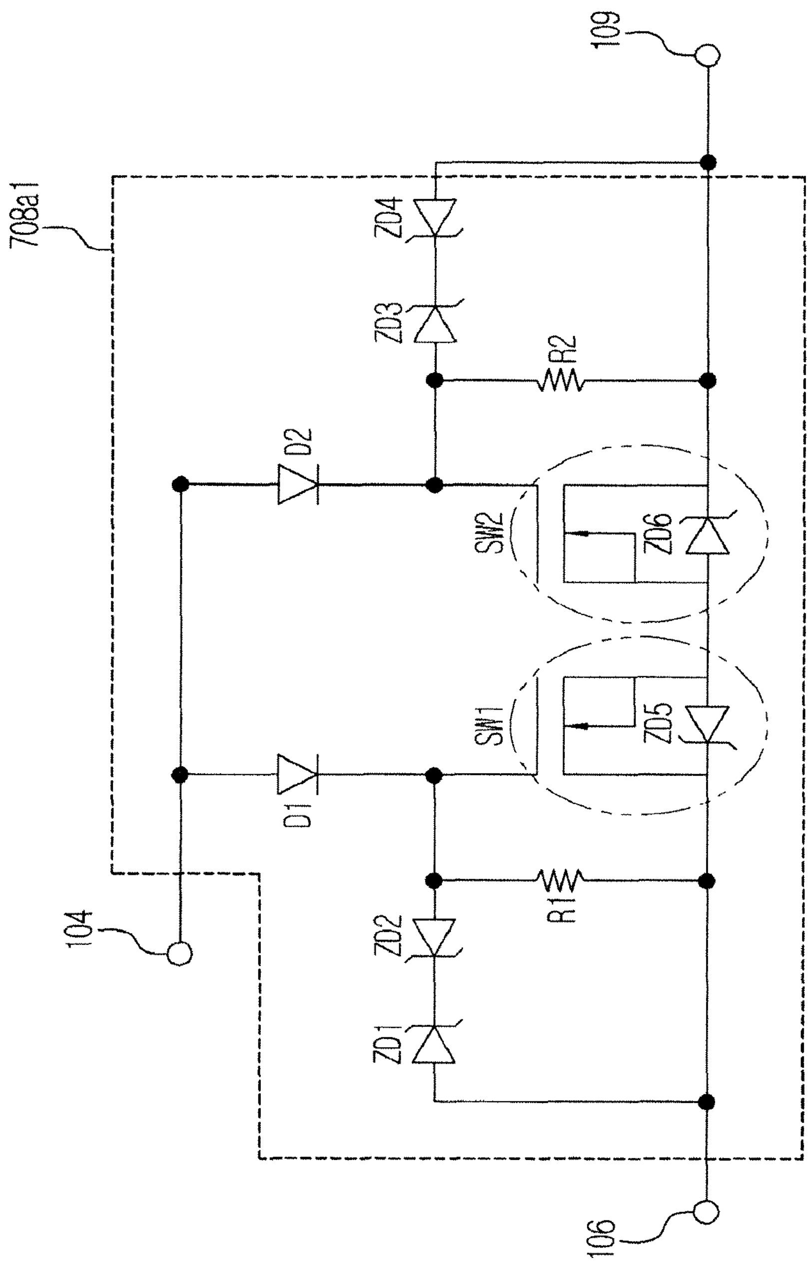


FIG. 11

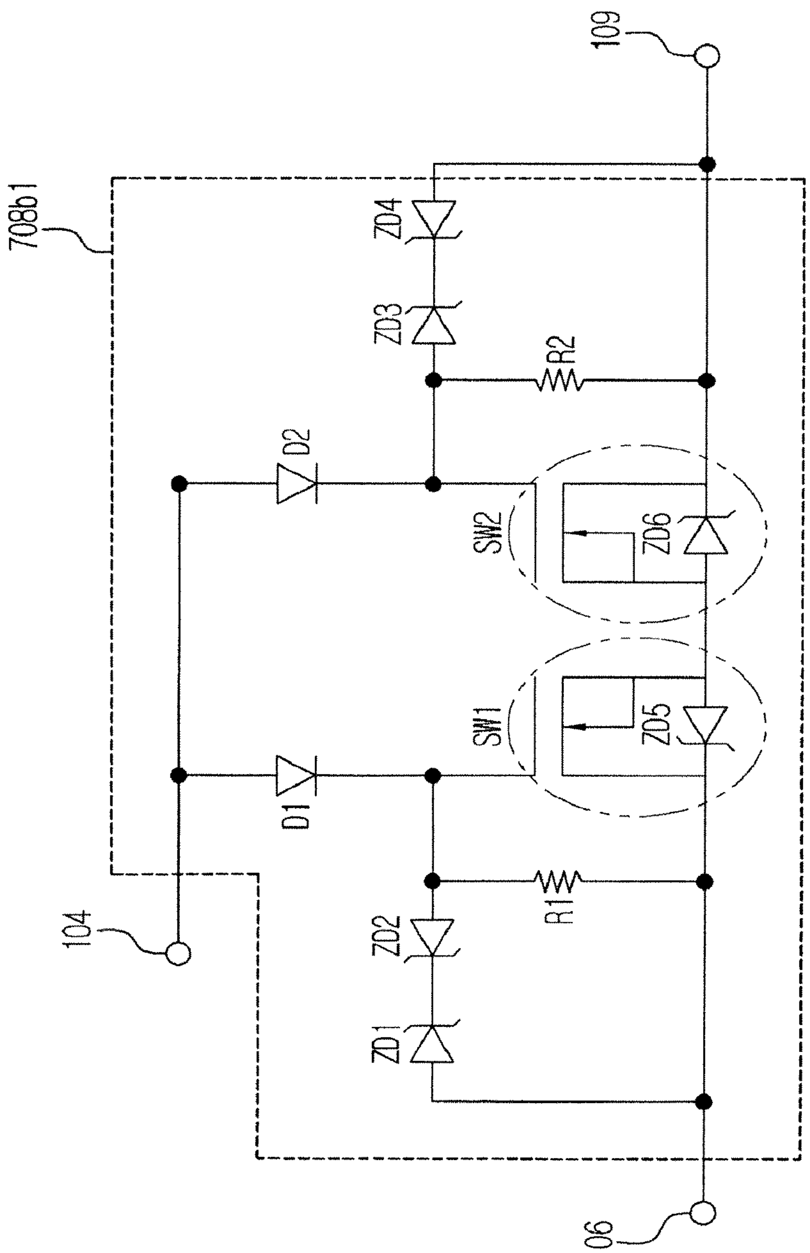


FIG. 12

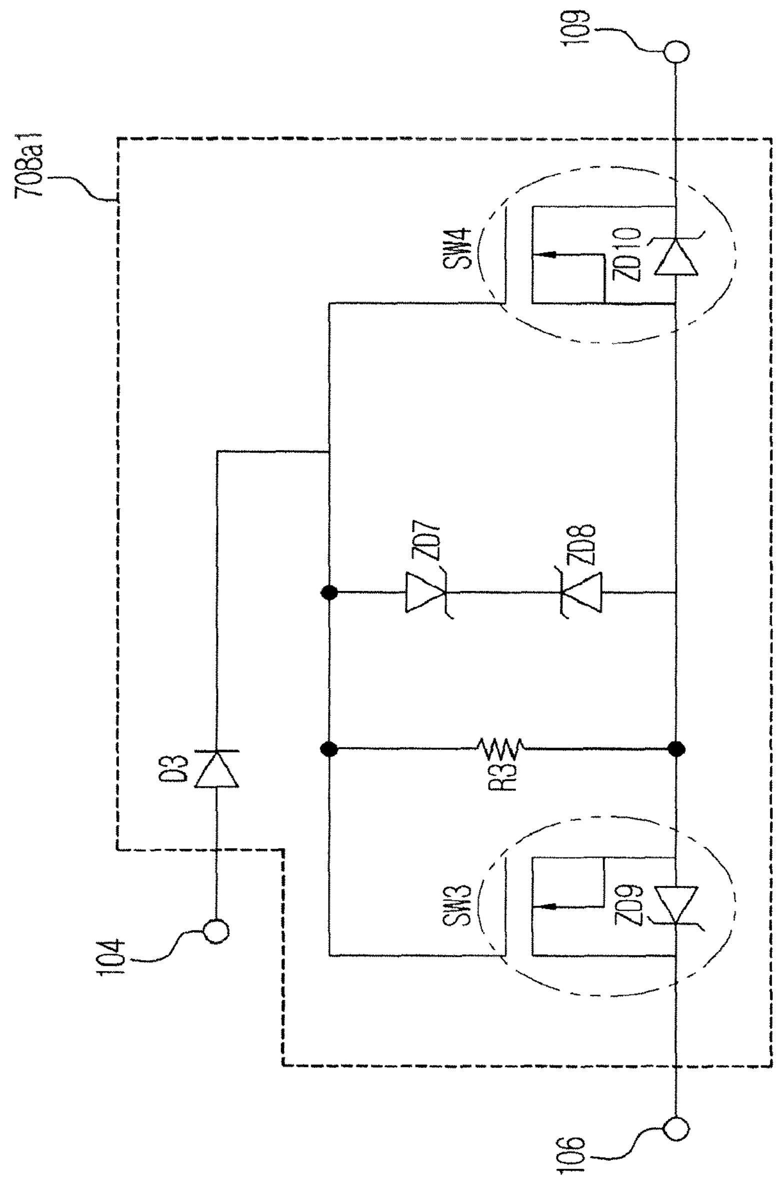


FIG. 13

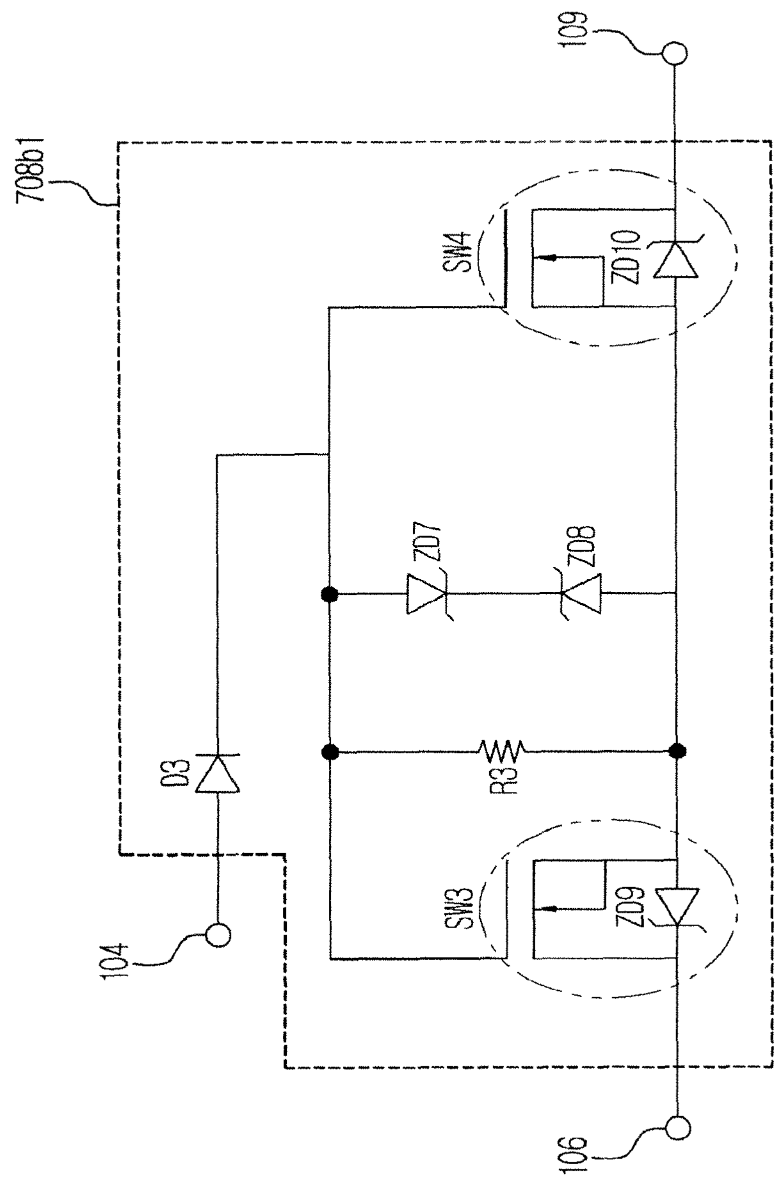


FIG. 14

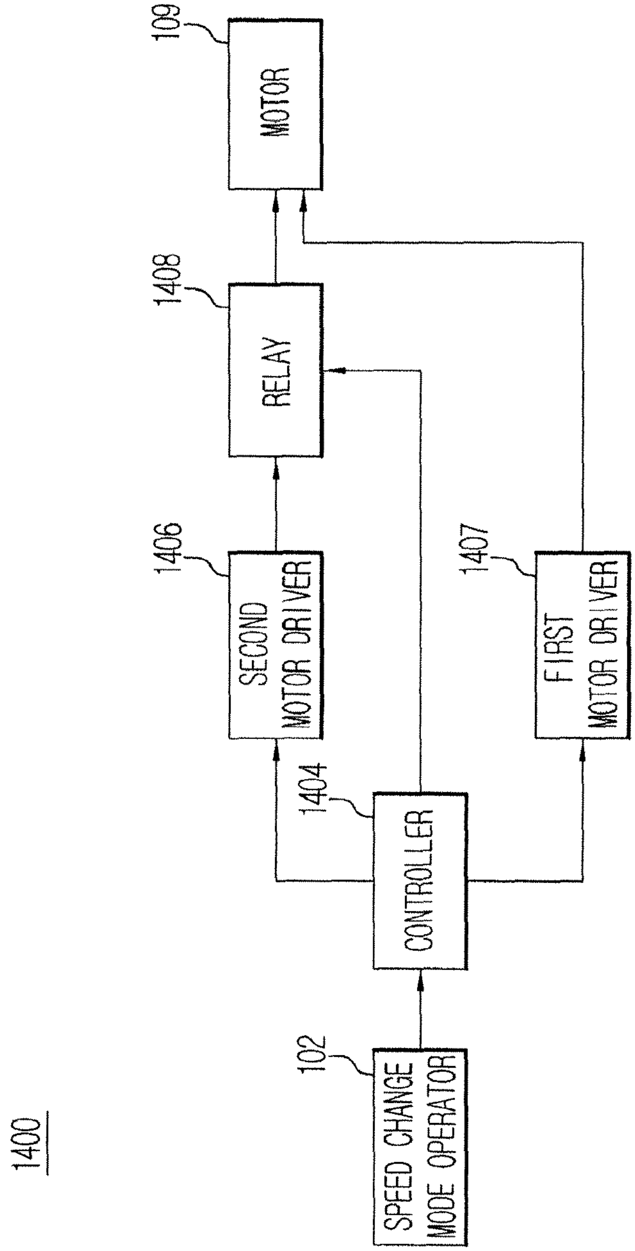

1400
SPEED CHANGE MODE OPERATOR
102
CONTROLLER
1404
SECOND MOTOR DRIVER
1406
FIRST MOTOR DRIVER
1407
RELAY
1408
MOTOR
109

FIG. 15

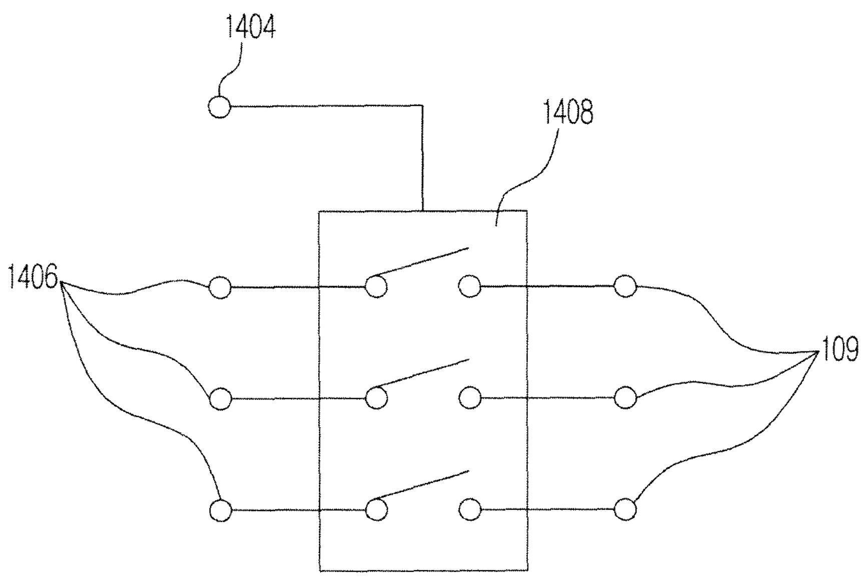


FIG. 16

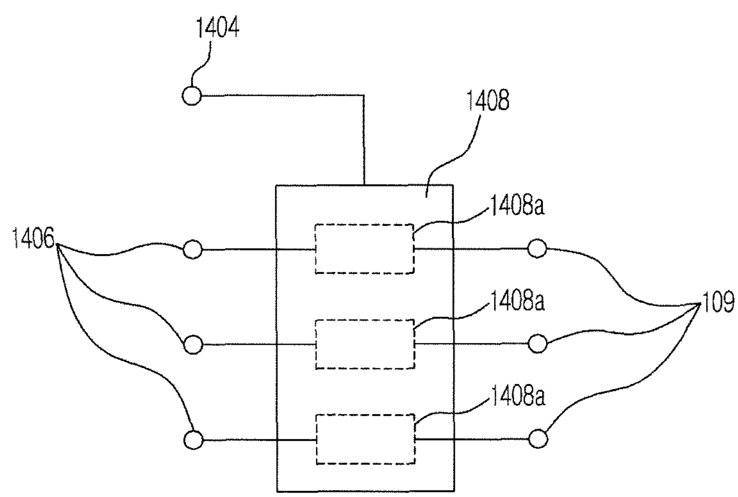


FIG. 17

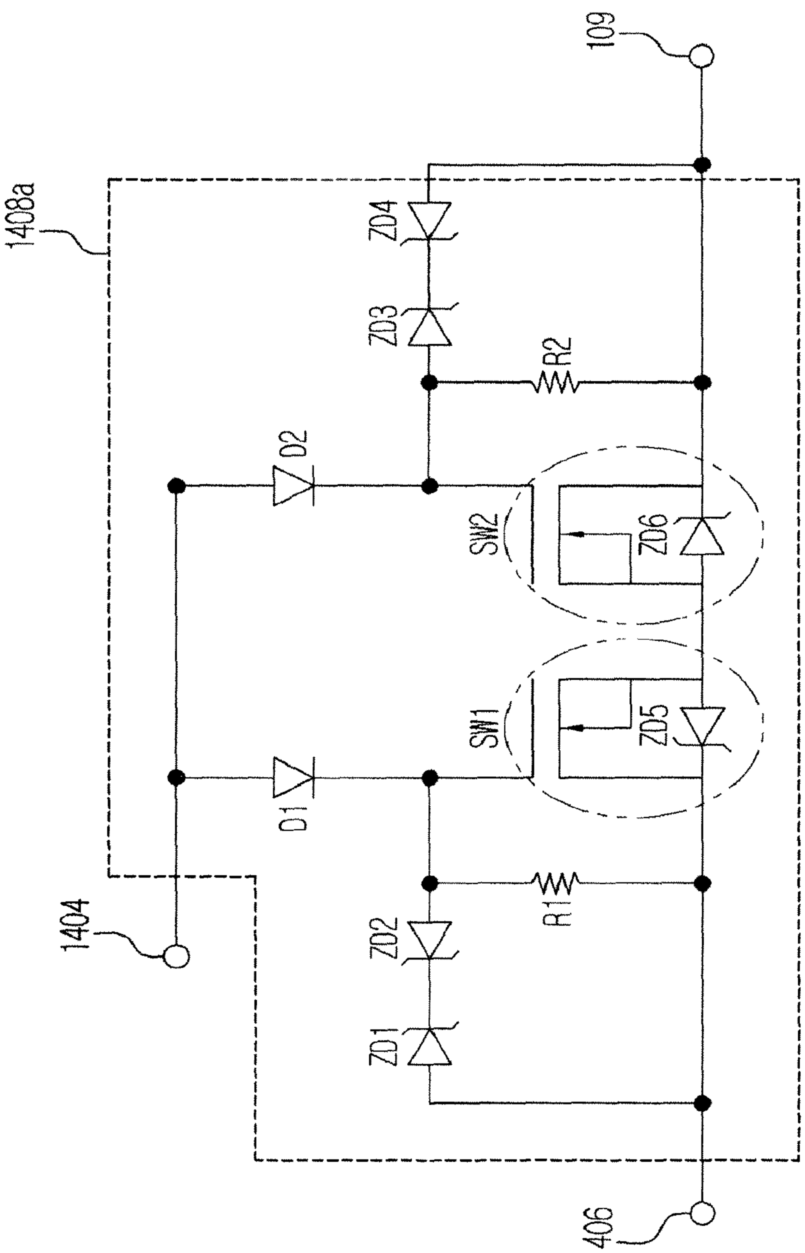


FIG. 18

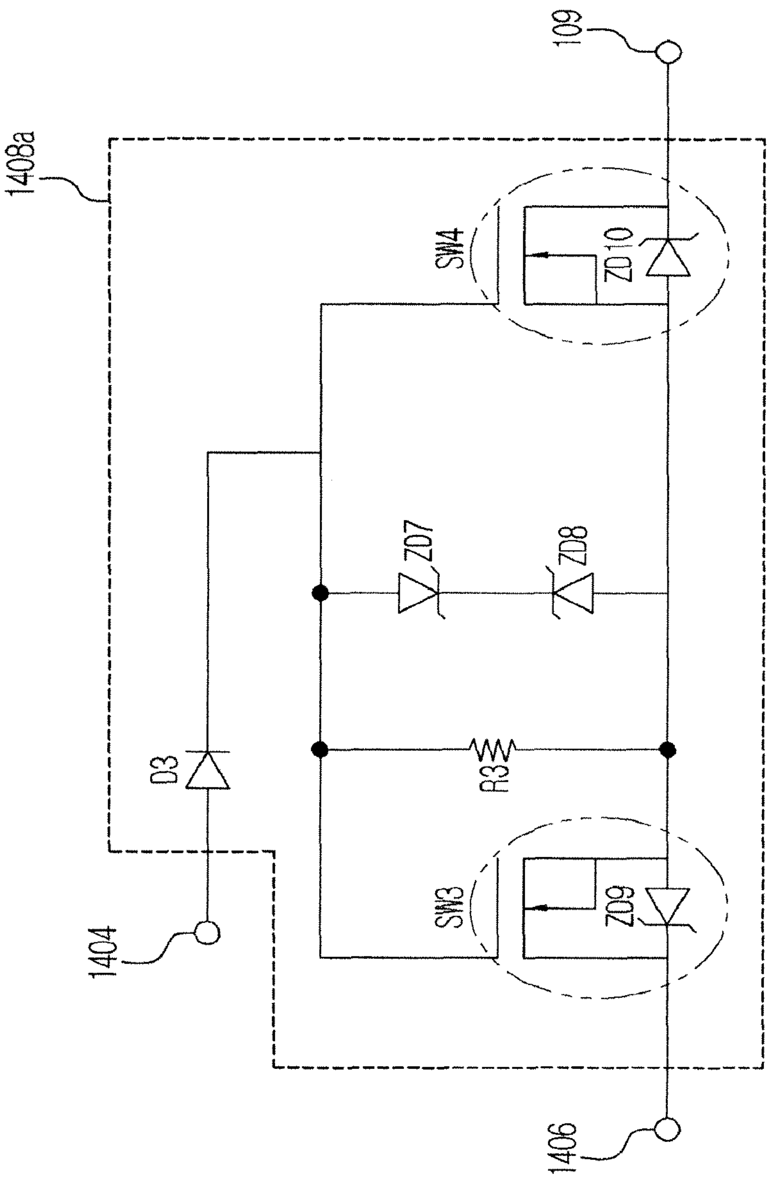


FIG. 19

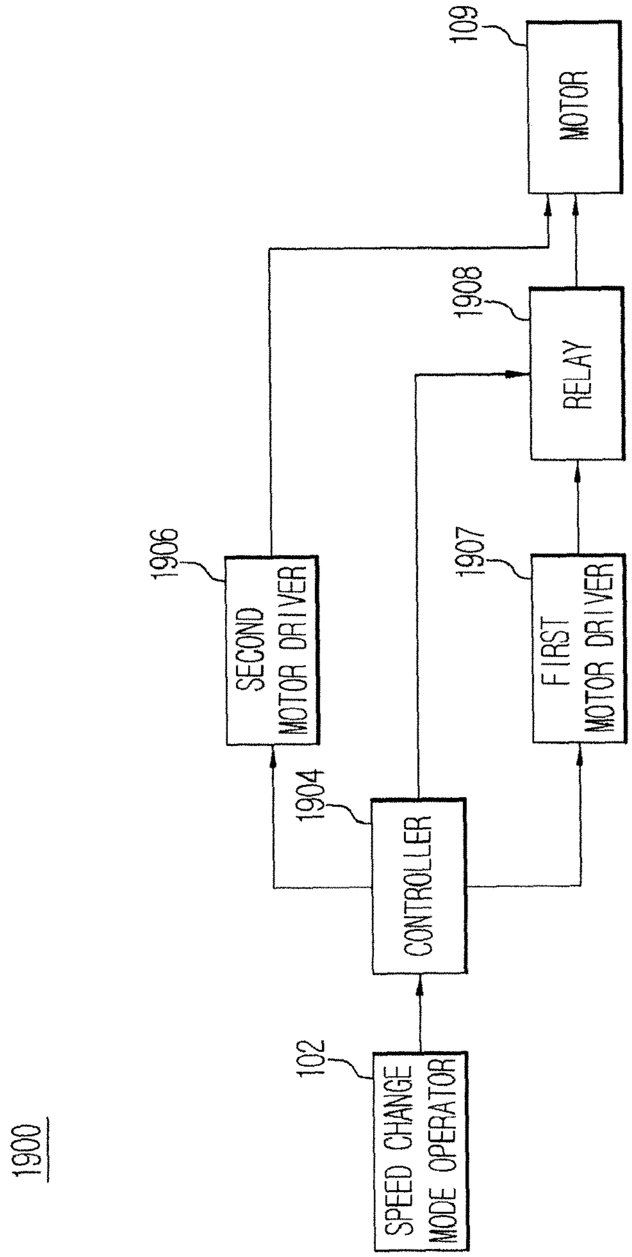

1900
SPEED CHANGE MODE OPERATOR
102
CONTROLLER
1904
SECOND MOTOR DRIVER
1906
FIRST MOTOR DRIVER
1907
RELAY
1908
MOTOR
109

FIG. 20

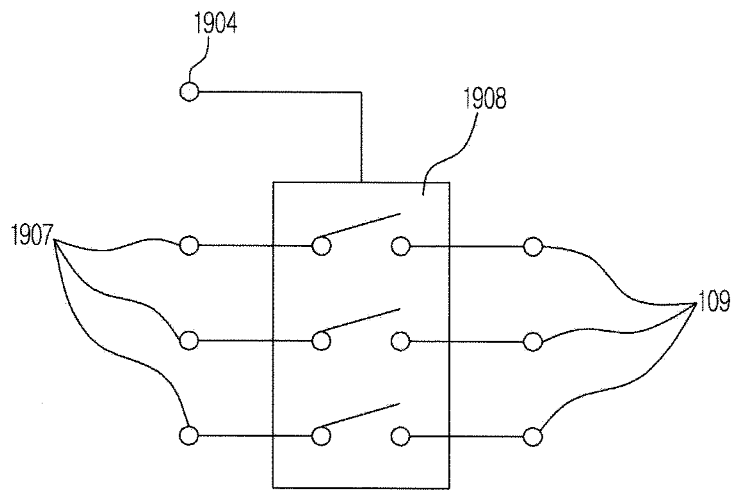


FIG. 21

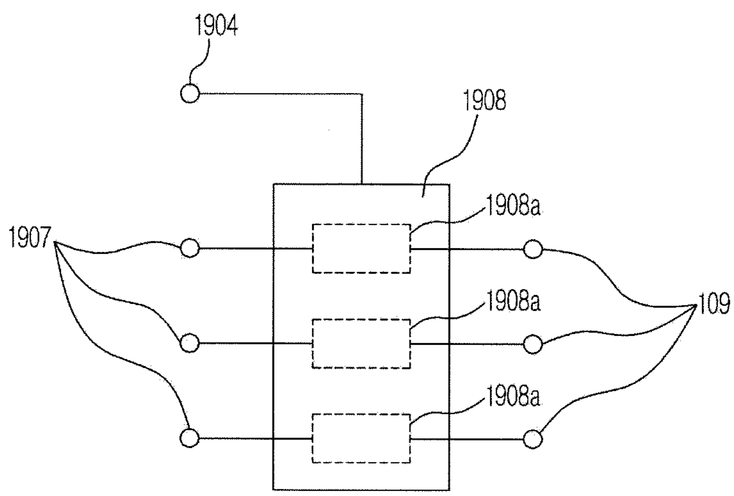


FIG. 22

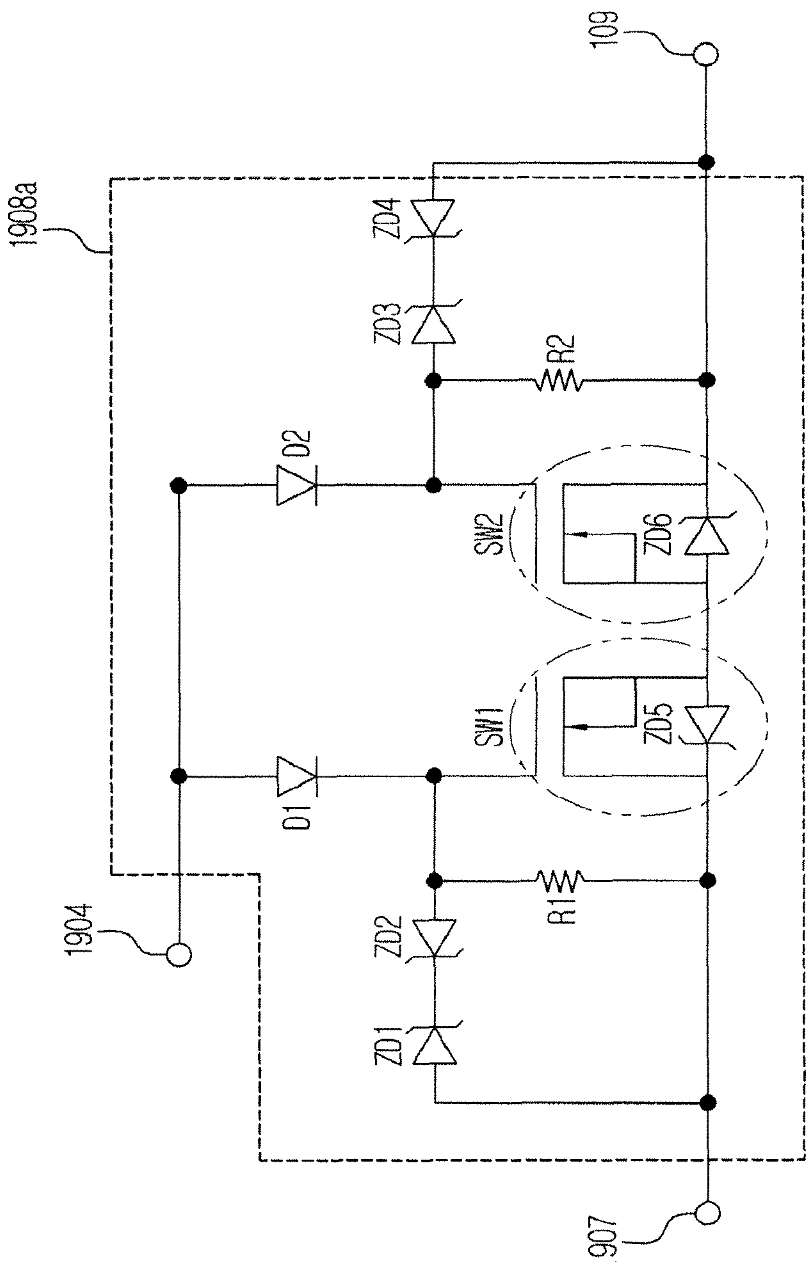


FIG. 23

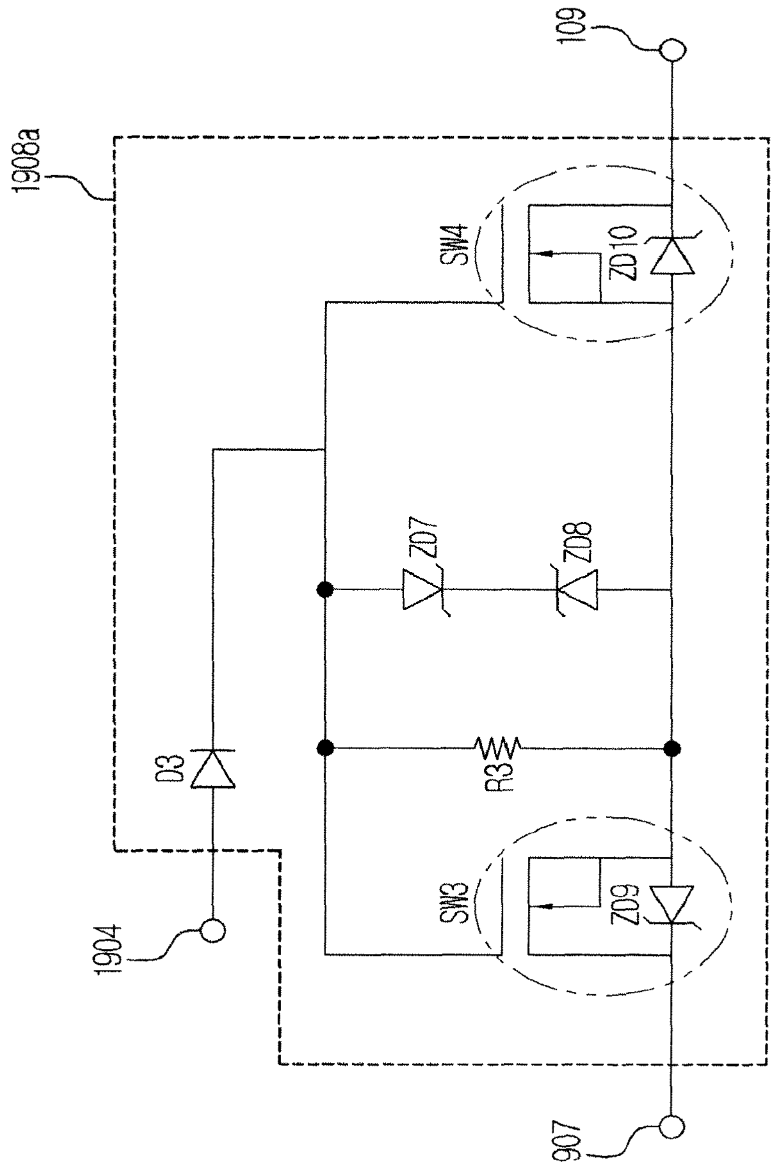


FIG. 24

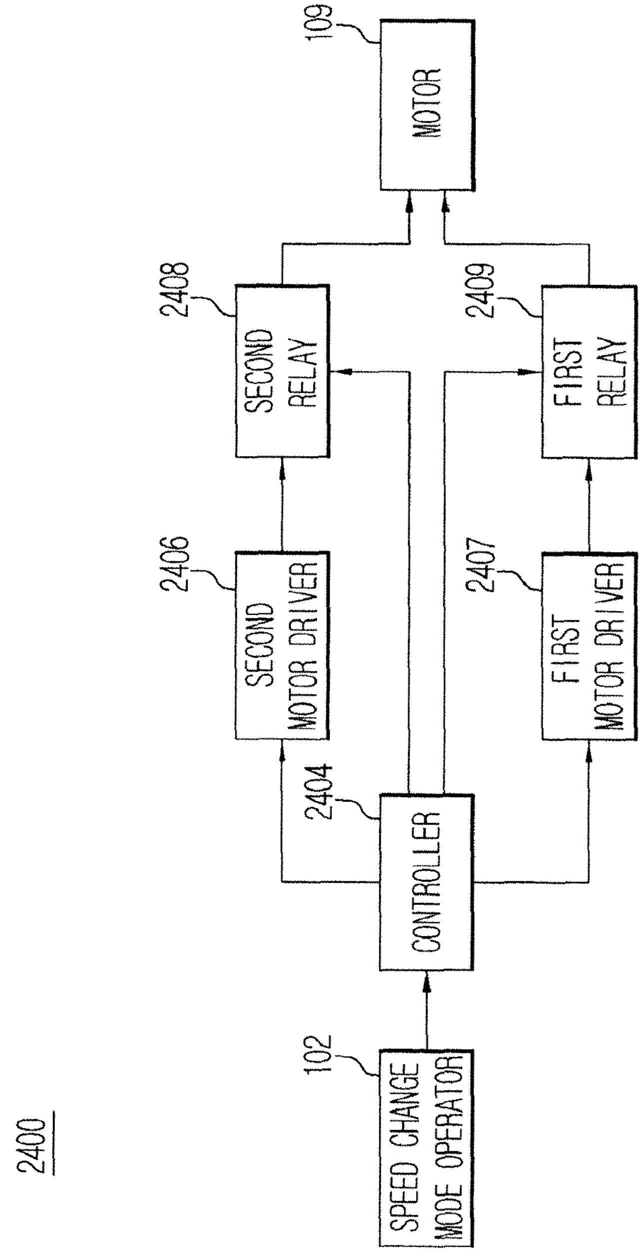

2400
102
SPEED CHANGE
MODE OPERATOR
2404
CONTROLLER
2406
SECOND
MOTOR DRIVER
2407
FIRST
MOTOR DRIVER
2408
SECOND
RELAY
2409
FIRST
RELAY
109
MOTOR

FIG. 25

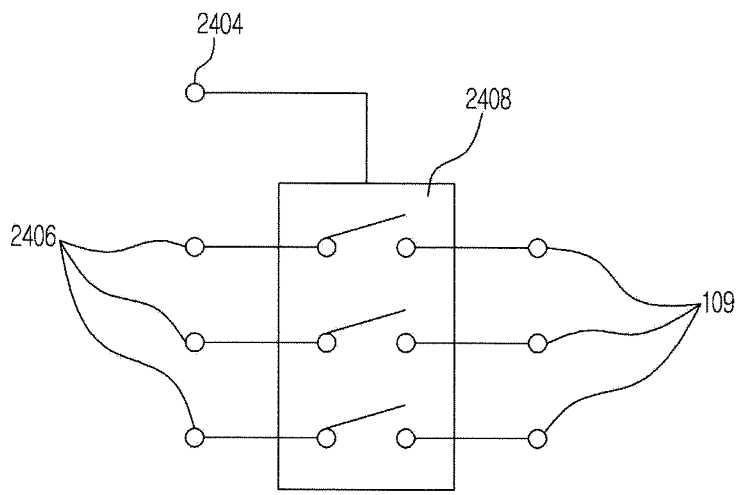


FIG. 26

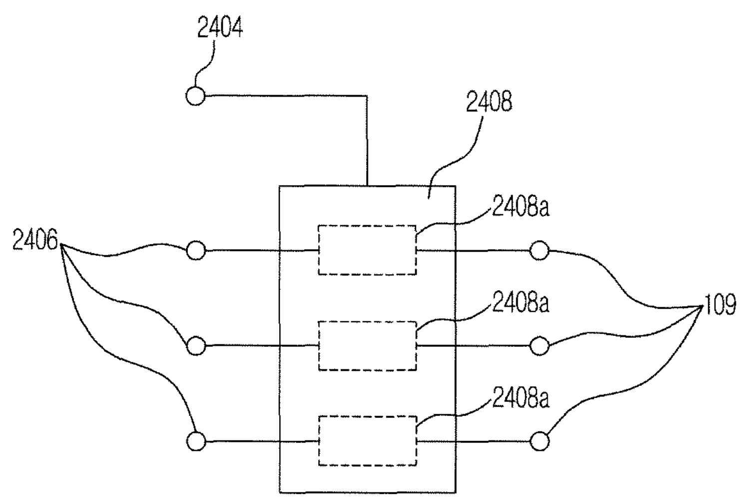


FIG. 27

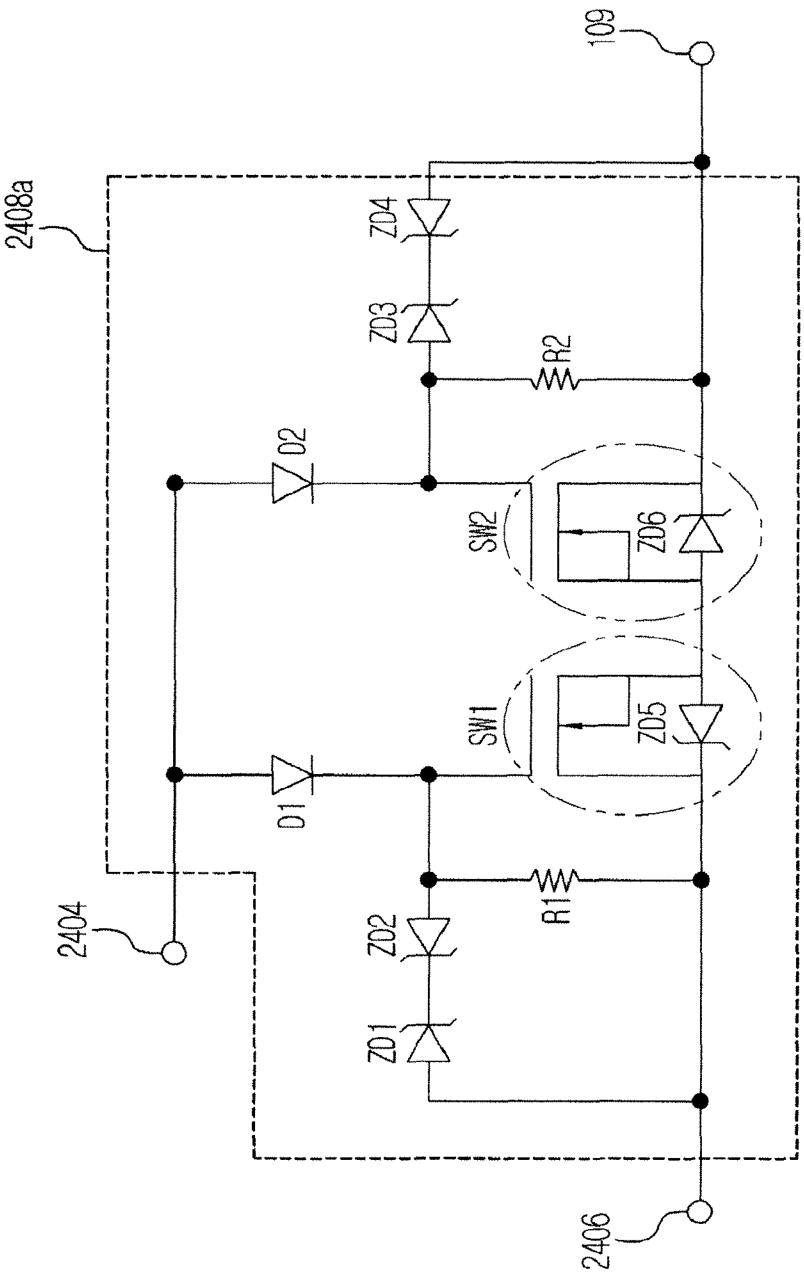


FIG. 28

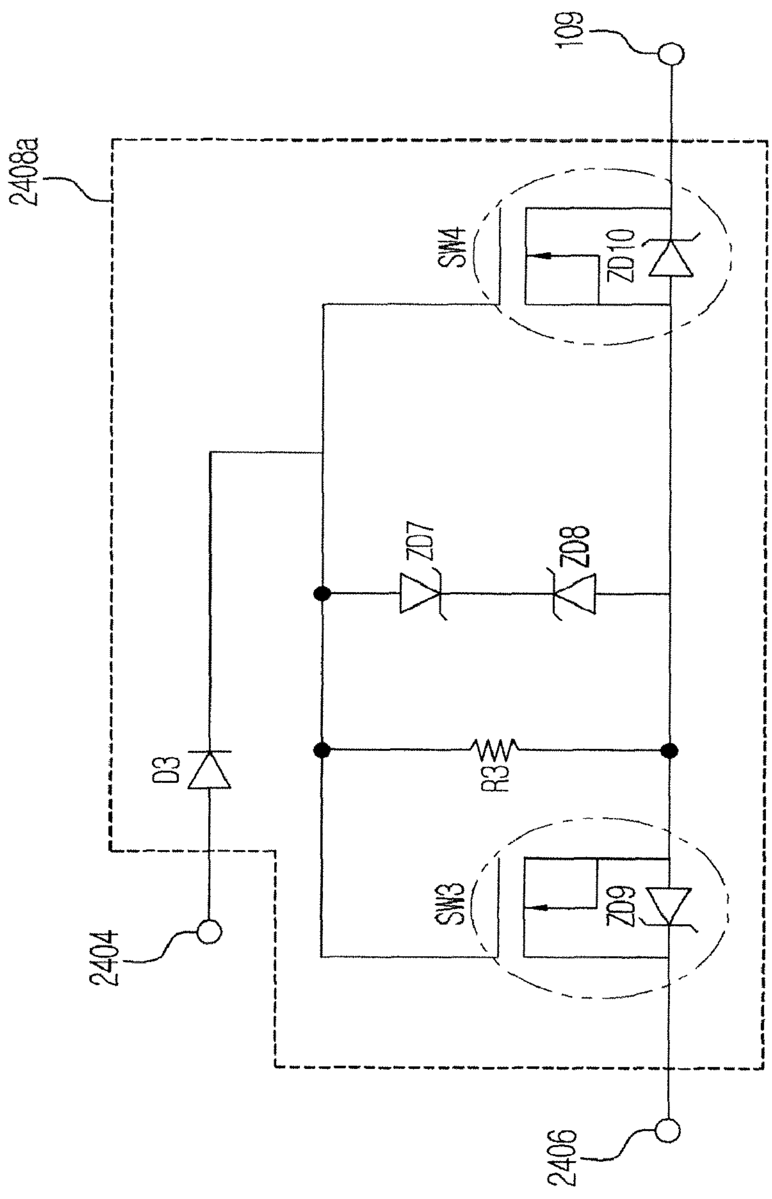


FIG. 29

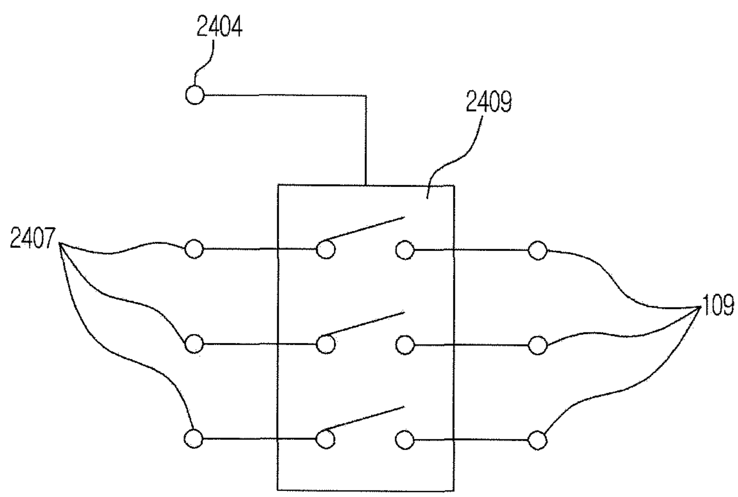


FIG. 30

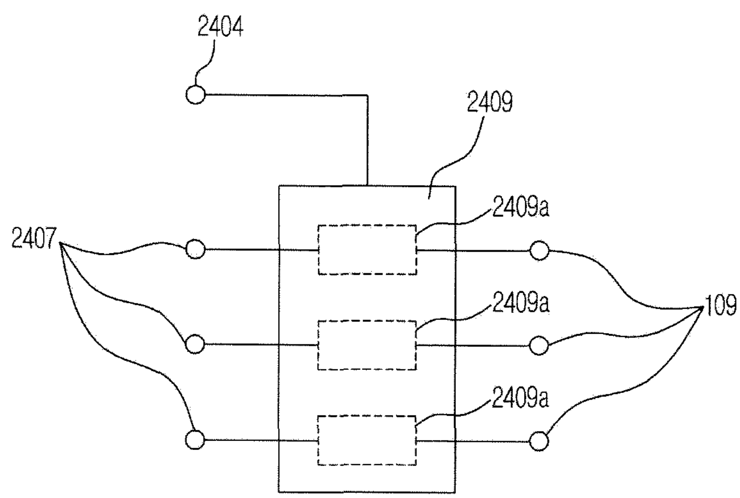


FIG. 31

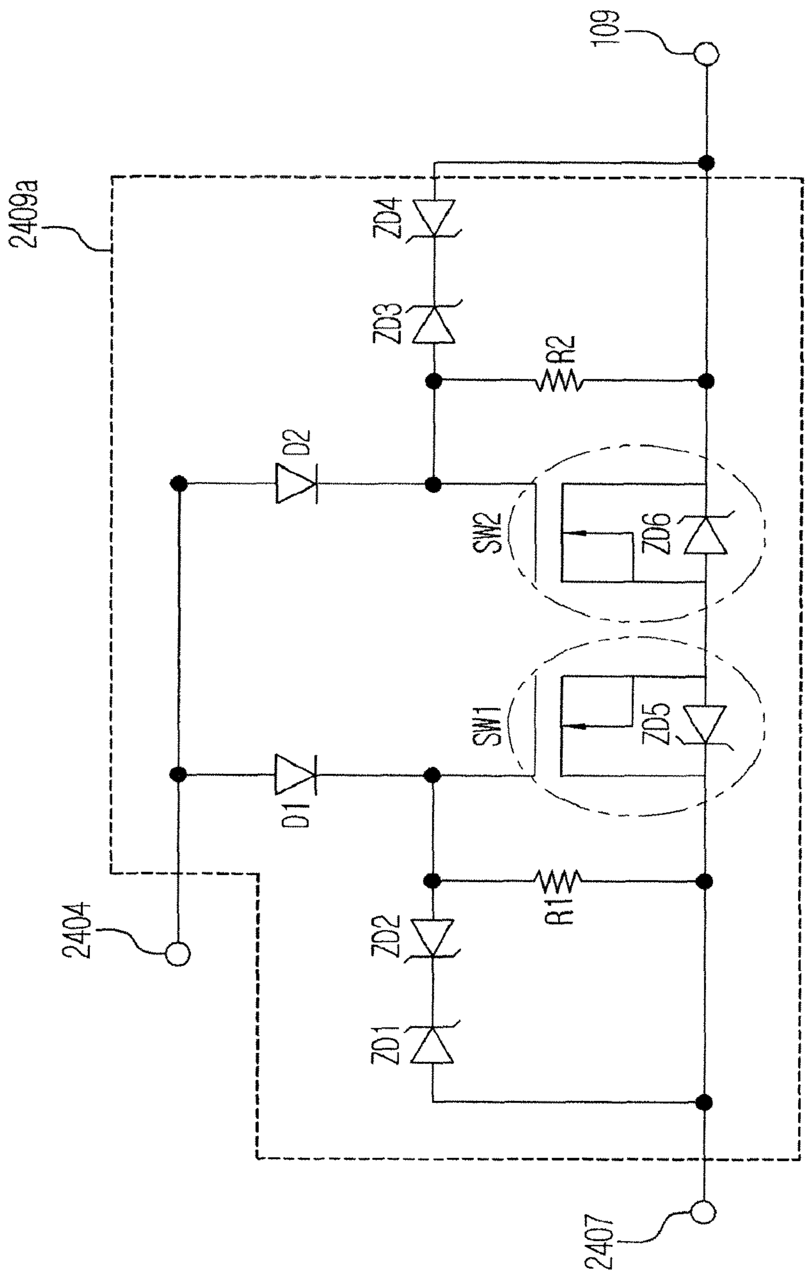
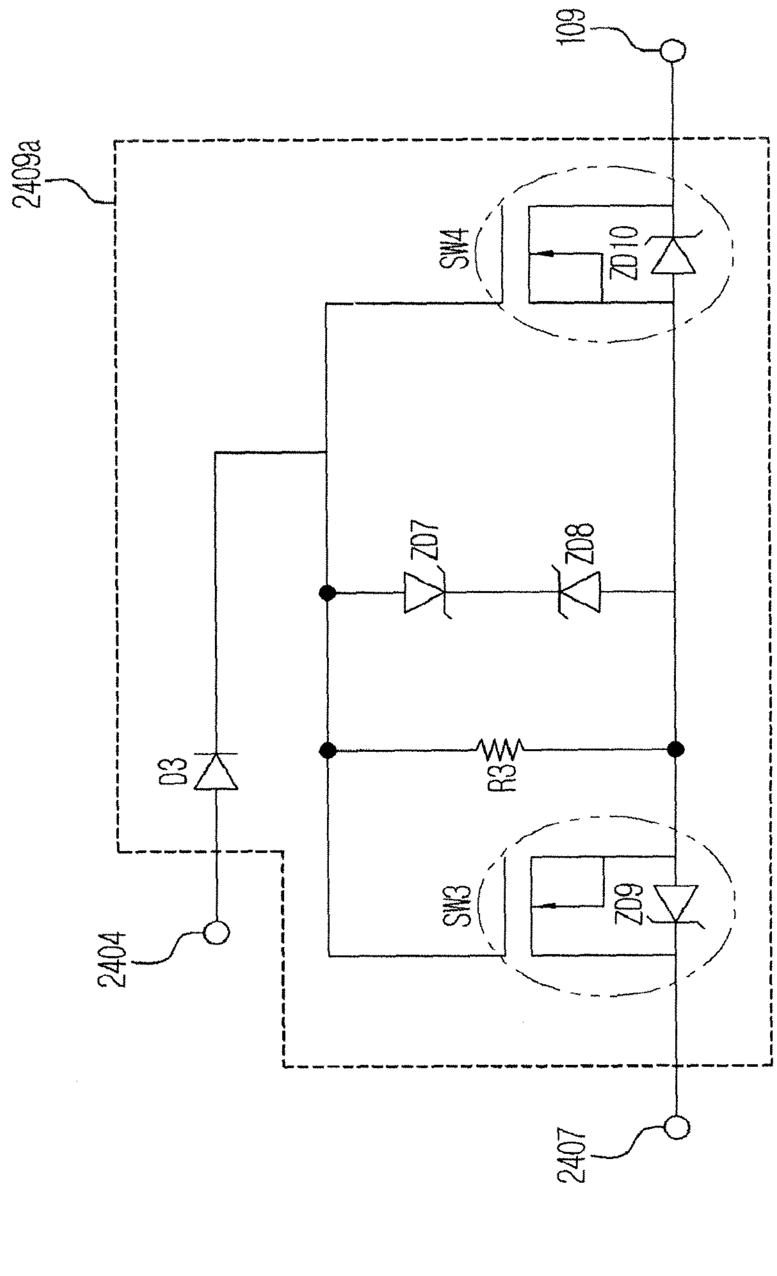


FIG. 32



# ELECTRIC BICYCLE DRIVING APPARATUS

## CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Korean Patent Application No. 2012-0104170, filed on Sep. 19, 2012 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

## BACKGROUND

1. Field

Embodiments of the present invention relate to an electric bicycle driving apparatus.

2. Description of the Related Art

In general, electric bicycle driving apparatuses are provided to drive electric bicycles.

Such a conventional electric bicycle driving apparatus reduces a speed change mode time by shortening a driving time of a motor driver when driving a motor of an electric bicycle in a high-speed mode or low-speed mode. To this end, the conventional electric bicycle driving apparatus includes a high-speed mode switching circuit and a low-speed mode switching circuit employing separate rectifying diodes and semiconductor switching devices.

However, in the conventional electric bicycle driving apparatus, heat may be generated from the rectifying diodes in a speed change mode. Furthermore, excessive heat generation may cause malfunction of the electric bicycle.

Also, in the conventional electric bicycle driving apparatus, because the high-speed mode switching circuit and low-speed mode switching circuit employing the rectifying diodes and semiconductor switching devices are driven in the speed change mode, the load to be driven may increase, resulting in a limitation in reducing consumption of battery power.

Moreover, in the conventional electric bicycle driving apparatus, because the high-speed mode switching circuit and low-speed mode switching circuit employing the rectifying diodes and semiconductor switching devices are driven in the speed change mode, there may be a limitation in suppressing an increase in cost of parts manufactured for the speed change mode.

## SUMMARY

Therefore, it is an aspect of the present invention to provide an electric bicycle driving apparatus which may rapidly reduce a speed change mode time.

It is another aspect of the present invention to provide an electric bicycle driving apparatus which may reduce heat generation to prevent malfunction.

It is another aspect of the present invention to provide an electric bicycle driving apparatus which may reduce the load to be driven, so as to reduce consumption of battery power.

It is a further aspect of the present invention to provide an electric bicycle driving apparatus which may suppress an increase in cost of parts manufactured for a speed change mode.

Additional aspects of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

In accordance with an aspect of the present invention, an electric bicycle driving apparatus includes a speed change mode operator to output a first speed change mode signal or a second speed change mode signal, a controller to receive the first speed change mode signal or second speed change mode signal output from the speed change mode operator and output a first control signal corresponding to the first speed change mode signal or a second control signal corresponding to the second speed change mode signal, a motor driver to, when the speed change mode operator outputs the first speed change mode signal, receive the first control signal and output a first motor driving signal to drive a motor in a first speed change mode, and, when the speed change mode operator outputs the second speed change mode signal, receive the second control signal and output a second motor driving signal to drive the motor, the motor being rotating with a driving force of the first motor driving signal, in a second speed change mode, and a relay to selectively receive a relay switching enable signal from the controller, the relay being turned on in response to the relay switching enable signal to provide at least one of the first motor driving signal and second motor driving signal to the motor.

## BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. **1** is a perspective view of an electric bicycle including an electric bicycle driving apparatus according to a first embodiment of the present invention;

FIG. **2** is a block diagram showing the configuration of the electric bicycle driving apparatus according to the first embodiment of the present invention;

FIG. **3** is a view showing an embodiment of a relay in FIG. **2**;

FIG. **4** is a view showing another embodiment of the relay in FIG. **2**;

FIG. **5** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **4**;

FIG. **6** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **4**;

FIG. **7** is a block diagram showing the configuration of an electric bicycle driving apparatus according to a second embodiment of the present invention;

FIG. **8** is a view showing an embodiment of a relay in FIG. **7**;

FIG. **9** is a view showing another embodiment of the relay in FIG. **7**;

FIG. **10** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **9**;

FIG. **11** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **9**;

FIG. **12** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **9**;

FIG. **13** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **9**;

FIG. **14** is a block diagram showing the configuration of an electric bicycle driving apparatus according to a third embodiment of the present invention;

FIG. **15** is a view showing an embodiment of a relay in FIG. **14**;

FIG. **16** is a view showing another embodiment of the relay in FIG. **14**;

FIG. **17** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **16**;

FIG. **18** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **16**;

FIG. **19** is a block diagram showing the configuration of an electric bicycle driving apparatus according to a fourth embodiment of the present invention;

FIG. **20** is a view showing an embodiment of a relay in FIG. **19**;

FIG. **21** is a view showing another embodiment of the relay in FIG. **19**;

FIG. **22** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **21**;

FIG. **23** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **21**;

FIG. **24** is a block diagram showing the configuration of an electric bicycle driving apparatus according to a fifth embodiment of the present invention;

FIG. **25** is a view showing an embodiment of a relay connected to a second motor driver, shown in FIG. **24**;

FIG. **26** is a view showing another embodiment of the relay connected to the second motor driver, shown in FIG. **24**;

FIG. **27** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **26**;

FIG. **28** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **26**;

FIG. **29** is a view showing an embodiment of a relay connected to a first motor driver, shown in FIG. **24**;

FIG. **30** is a view showing another embodiment of the relay connected to the first motor driver, shown in FIG. **24**;

FIG. **31** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **30**; and

FIG. **32** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **30**.

## DETAILED DESCRIPTION

Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

<First Embodiment>

FIG. **1** is a perspective view of an electric bicycle including an electric bicycle driving apparatus according to a first embodiment of the present invention, and FIG. **2** is a block diagram showing the configuration of the electric bicycle driving apparatus according to the first embodiment of the present invention.

FIG. **3** is a view showing an embodiment of a relay in FIG. **2**, and FIG. **4** is a view showing another embodiment of the relay in FIG. **2**.

FIG. **5** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **4**, and FIG. **6** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **4**.

First, referring to FIG. **1**, the electric bicycle driving apparatus according to the first embodiment of the present invention, denoted by reference numeral **100**, is provided at one side and the other side of the electric bicycle, denoted by reference numeral **10**.



Next, referring to FIGS. **2** to **6**, the electric bicycle driving apparatus **100** according to the first embodiment of the present invention includes a speed change mode operator **102**, a controller **104**, a motor driver **106**, a relay **108**, and a motor **109**.

The speed change mode operator **102** is provided to output a first speed change mode signal or a second speed change mode signal.

The speed change mode operator **102** may be provided at a portion of a handlebar of the electric bicycle **10**.

The controller **104** receives the first speed change mode signal or second speed change mode signal output from the speed change mode operator **102** and outputs a first control signal corresponding to the first speed change mode signal or a second control signal corresponding to the second speed change mode signal.

The controller **104** may include an electronic controller unit (ECU) or a micro controller unit (MCU).

When the speed change mode operator **102** outputs a low-speed mode signal corresponding to the first speed change mode signal, the motor driver **106** receives the first control signal and outputs a first motor driving signal to drive the motor **109** in a low-speed mode corresponding to a first speed change mode. Also, when the speed change mode operator **102** outputs a high-speed mode signal corresponding to the second speed change mode signal, the motor driver **106** receives the second control signal and outputs a second motor driving signal to drive the motor **109**, which is rotating with a driving force of the first motor driving signal, in a high-speed mode corresponding to a second speed change mode.

On the other hand, when the speed change mode operator **102** outputs the high-speed mode signal corresponding to the first speed change mode signal, the motor driver **106** receives the first control signal and outputs the first motor driving signal to drive the motor **109** in the high-speed mode corresponding to the first speed change mode. Also, when the speed change mode operator **102** outputs the low-speed mode signal corresponding to the second speed change mode signal, the motor driver **106** receives the second control signal and outputs the second motor driving signal to drive the motor **109**, which is rotating with the driving force of the first motor driving signal, in the low-speed mode corresponding to the second speed change mode.

The relay **108** selectively receives a relay switching enable signal from the controller **104** so as to be turned on in response to the relay switching enable signal. Upon being turned on, the relay **108** provides at least one of the first motor driving signal and second motor driving signal to the motor **109**.

As shown in FIGS. **2** to **6**, the relay **108** may be electrically connected between an output stage of the motor driver **106** and an input stage of the motor **109**.

The relay **108** has an internal circuit **108***a*, which may include a first rectifying diode D**1**, a first switching device SW**1**, a first resistor R**1**, a second rectifying diode D**2**, a second switching device SW**2**, and a second resistor R**2**, as shown in FIGS. **4** and **5**.

The first rectifying diode D**1** may be electrically connected with one side of the controller **104**, and the first switching device SW**1** may be electrically connected with the first rectifying diode D**1** and the motor driver **106**.

Here, the first switching device SW**1** may include at least one of a metal-oxide semiconductor field effect transistor (MOSFET) and a bipolar junction transistor (BJT).

In this case, the first switching device SW**1** may further include at least one Zener diode ZD**5** which is electrically connected with the first resistor R**1**, and the second switching device SW**2** to be described later, to cut off an abnormal signal from the motor **109**.

The first resistor R**1** may be electrically connected with the first rectifying diode D**1**, the first switching device SW**1** and the motor driver **106**, and the second rectifying diode D**2** may be electrically connected with the other side of the controller **104**.

The second switching device SW**2** may be electrically connected with the second rectifying diode D**2**, the first switching device SW**1** and the motor **109**, and the second resistor R**2** may be electrically connected with the second rectifying diode D**2**, the second switching device SW**2** and the motor **109**.

Here, the second switching device SW**2** may include at least one of a MOSFET and a BJT.

In this case, the second switching device SW**2** may further include at least one Zener diode ZD**6** which is electrically connected with the first switching device SW**1** and the second resistor R**2** to cut off an abnormal signal from the motor driver **106**.

In the relay **108** with the above configuration, when the first and second switching devices SW**1** and SW**2** are turned on in response to the relay switching enable signal from the controller **104**, rectified through the first and second rectifying diodes D**1** and D**2**, the level of the first motor driving signal or second motor driving signal supplied from the motor driver **106** is adjusted by the first resistor R**1** and in turn by the second resistor R**2**, and the first motor driving signal or second motor driving signal of the adjusted level is then supplied to the motor **109**.

Also, the internal circuit **108***a* of the relay **108** may further include one or more Zener diodes ZD**1** and ZD**2** which are electrically connected with the motor driver **106** and the first resistor R**1** to cut off an abnormal signal from the motor driver **106**.

Also, the internal circuit **108***a* of the relay **108** may further include one or more Zener diodes ZD**3** and ZD**4** which are electrically connected with the second resistor R**2** and the motor **109** to cut off an abnormal signal from the motor **109**.

Alternatively, as shown in FIGS. **4** and **6**, the internal circuit **108***a* of the relay **108** may include a third rectifying diode D**3**, a third switching device SW**3**, a third resistor R**3**, and a fourth switching device SW**4**.

The third rectifying diode D**3** may be electrically connected with one side of the controller **104**, and the third switching device SW**3** may be electrically connected with the third rectifying diode D**3** and the motor driver **106**.

Here, the third switching device SW**3** may include at least one of a MOSFET and a BJT.

In this case, the third switching device SW**3** may further include at least one Zener diode ZD**9** which is electrically connected with the motor driver **106** and the third resistor R**3** to cut off an abnormal signal from the motor **109**.

The third resistor R**3** may be electrically connected with the third rectifying diode D**3** and the third switching device SW**3**, and the fourth switching device SW**4** may be electrically connected with the third rectifying diode D**3**, the third resistor R**3** and the motor **109**.

Here, the fourth switching device SW**4** may include at least one of a MOSFET and a BJT.

In this case, the fourth switching device SW**4** may further include at least one Zener diode ZD**10** which is electrically connected with the third resistor R**3** and the motor **109** to cut off an abnormal signal from the motor driver **106**.

Also, the internal circuit **108***a* of the relay **108** may further include one or more Zener diodes ZD**7** and ZD**8** which are electrically connected with the third resistor R**3**, the third rectifying diode D**3** and the fourth switching device SW**4** to cut off an abnormal signal from at least one of the motor driver **106** and motor **109**.

As stated above, the electric bicycle driving apparatus **100** according to the first embodiment of the present invention includes the speed change mode operator **102**, the controller **104**, the motor driver **106**, the relay **108**, and the motor **109**.

Therefore, in the electric bicycle driving apparatus **100** according to the first embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the motor driver **106** for the speed change mode, is supplied to the motor **109**, it may be possible to provide a faster switching response characteristic for a turn-on operation, thereby rapidly reducing a speed change mode time.

Further, in the electric bicycle driving apparatus **100** according to the first embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the motor driver **106** for the speed change mode, is supplied to the motor **109**, it may be possible to reduce heat generation to prevent malfunction.

Moreover, in the electric bicycle driving apparatus **100** according to the first embodiment of the present invention, the unified relay **108** is employed, thereby making it possible to suppress an increase in cost of parts manufactured for the speed change mode.

<Second Embodiment>

FIG. **7** is a block diagram showing the configuration of an electric bicycle driving apparatus according to a second embodiment of the present invention, FIG. **8** is a view showing an embodiment of a relay in FIG. **7**, and FIG. **9** is a view showing another embodiment of the relay in FIG. **7**.

FIG. **10** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **9**, and FIG. **11** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **9**.

FIG. **12** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **9**, and FIG. **13** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **9**.

Referring to FIGS. **7** to **13**, the electric bicycle driving apparatus according to the second embodiment of the present invention, denoted by reference numeral **700**, includes a speed change mode operator **102**, a controller **104**, a motor driver **106**, a relay **708**, and a motor **109**.

The speed change mode operator **102** is provided to output a first speed change mode signal or a second speed change mode signal.

The speed change mode operator **102** may be provided at a portion of a handlebar of the electric bicycle **10**.

The controller **104** receives the first speed change mode signal or second speed change mode signal output from the speed change mode operator **102** and outputs a first control signal corresponding to the first speed change mode signal or a second control signal corresponding to the second speed change mode signal.

The controller **104** may include an electronic controller unit (ECU) or a micro controller unit (MCU).

When the speed change mode operator **102** outputs a low-speed mode signal corresponding to the first speed change mode signal, the motor driver **106** receives the first control signal and outputs a first motor driving signal to drive the motor **109** in a low-speed mode corresponding to a first speed change mode. Also, when the speed change mode operator **102** outputs a high-speed mode signal corresponding to the second speed change mode signal, the motor driver **106** receives the second control signal and outputs a second motor driving signal to drive the motor **109**, which is rotating with a driving force of the first motor driving signal, in a high-speed mode corresponding to a second speed change mode.

On the other hand, when the speed change mode operator **102** outputs the high-speed mode signal corresponding to the first speed change mode signal, the motor driver **106** receives the first control signal and outputs the first motor driving signal to drive the motor **109** in the high-speed mode corresponding to the first speed change mode. Also, when the speed change mode operator **102** outputs the low-speed mode signal corresponding to the second speed change mode signal, the motor driver **106** receives the second control signal and outputs the second motor driving signal to drive the motor **109**, which is rotating with the driving force of the first motor driving signal, in the low-speed mode corresponding to the second speed change mode.

The relay **708** selectively receives a relay switching enable signal from the controller **104** so as to be turned on in response to the relay switching enable signal. Upon being turned on, the relay **708** provides the first motor driving signal and the second motor driving signal to the motor **109**.

As shown in FIGS. **7** to **13**, the relay **708** includes a first relay **708*a*** to provide the first motor driving signal output from the motor driver **106** to the motor **109**, and a second relay **708*b*** to provide the second motor driving signal output from the motor driver **106** to the motor **109**.

The first relay **708*a*** and the second relay **708*b*** may be electrically connected between an output stage of the motor driver **106** and an input stage of the motor **109**.

As shown in FIGS. **9** to **11**, the first relay **708*a*** selectively receives a first relay switching enable signal of the relay switching enable signal so as to be turned on in response to the first relay switching enable signal. Upon being turned on, the first relay **708*a*** supplies the first motor driving signal to the motor **109**. Also, the second relay **708*b*** selectively receives a second relay switching enable signal of the relay switching enable signal so as to be turned on in response to the second relay switching enable signal. Upon being turned on, the second relay **708*b*** supplies the second motor driving signal to the motor **109**.

The first relay **708*a*** and the second relay **708*b*** have internal circuits **708*a*1** and **708*b*1**, respectively, each of which may include a first rectifying diode D**1**, a first switching device SW**1**, a first resistor R**1**, a second rectifying diode D**2**, a second switching device SW**2**, and a second resistor R**2**.

The first rectifying diode D**1** may be electrically connected with one side of the controller **104**, and the first switching device SW**1** may be electrically connected with the first rectifying diode D**1** and the motor driver **106**.

Here, the first switching device SW**1** may include at least one of a metal-oxide semiconductor field effect transistor (MOSFET) and a bipolar junction transistor (BJT).

In this case, the first switching device SW**1** may further include at least one Zener diode ZD**5** which is electrically connected with the first resistor R**1**, and the second switching device SW**2** to be described later, to cut off an abnormal signal from the motor **109**.

The first resistor R**1** may be electrically connected with the first rectifying diode D**1**, the first switching device SW**1** and the motor driver **106**, and the second rectifying diode D**2** may be electrically connected with the other side of the controller **104**.

The second switching device SW**2** may be electrically connected with the second rectifying diode D**2**, the first switching device SW**1** and the motor **109**, and the second resistor R**2** may be electrically connected with the second rectifying diode D**2**, the second switching device SW**2** and the motor **109**.

Here, the second switching device SW**2** may include at least one of a MOSFET and a BJT.

In this case, the second switching device SW**2** may further include at least one Zener diode ZD**6** which is electrically connected with the first switching device SW**1** and the second resistor R**2** to cut off an abnormal signal from the motor driver **106**.

In each of the first relay **708*a*** and second relay **708*b*** with the above configuration, when the first and second switching devices SW**1** and SW**2** are turned on in response to the relay switching enable signal from the controller **104**, rectified through the first and second rectifying diodes D**1** and D**2**, the level of the first motor driving signal or second motor driving signal supplied from the motor driver **106** is adjusted by the first resistor R**1** and in turn by the second resistor R**2**, and the first motor driving signal or second motor driving signal of the adjusted level is then supplied to the motor **109**.

Also, each of the internal circuits **708*a*1** and **708*b*1** of the first relay **708*a*** and second relay **708*b*** may further include one or more Zener diodes ZD**1** and ZD**2** which are electrically connected with the motor driver **106** and the first resistor R**1** to cut off an abnormal signal from the motor driver **106**.

Also, each of the internal circuits **708*a*1** and **708*b*1** of the first relay **708*a*** and second relay **708*b*** may further include one or more Zener diodes ZD**3** and ZD**4** which are electrically connected with the second resistor R**2** and the motor **109** to cut off an abnormal signal from the motor **109**.

Alternatively, as shown in FIGS. **9**, **12** and **13**, the first relay **708*a*** selectively receives the first relay switching enable signal of the relay switching enable signal so as to be turned on in response to the first relay switching enable signal. Upon being turned on, the first relay **708*a*** supplies the first motor driving signal to the motor **109**. Also, the second relay **708*b*** selectively receives the second relay switching enable signal of the relay switching enable signal so as to be turned on in response to the second relay switching enable signal. Upon being turned on, the second relay **708*b*** supplies the second motor driving signal to the motor **109**.

Each of the internal circuits **708*a*1** and **708*b*1** of the first relay **708*a*** and second relay **708*b*** may include a third rectifying diode D**3**, a third switching device SW**3**, a third resistor R**3**, and a fourth switching device SW**4**.

The third rectifying diode D**3** may be electrically connected with one side of the controller **104**, and the third switching device SW**3** may be electrically connected with the third rectifying diode D**3** and the motor driver **106**.

Here, the third switching device SW**3** may include at least one of a MOSFET and a BJT.

In this case, the third switching device SW**3** may further include at least one Zener diode ZD**9** which is electrically connected with the motor driver **106** and the third resistor R**3** to cut off an abnormal signal from the motor **109**.

The third resistor R**3** may be electrically connected with the third rectifying diode D**3** and the third switching device SW**3**, and the fourth switching device SW**4** may be electrically connected with the third rectifying diode D**3**, the third resistor R**3** and the motor **109**.

Here, the fourth switching device SW**4** may include at least one of a MOSFET and a BJT.

In this case, the fourth switching device SW**4** may further include at least one Zener diode ZD**10** which is electrically connected with the third resistor R3 and the motor **109** to cut off an abnormal signal from the motor driver **106**.

Also, each of the internal circuits **708***a***1** and **708***b***1** of the first relay **708***a* and second relay **708***b* may further include one or more Zener diodes ZD**7** and ZD**8** which are electrically connected with the third resistor R**3**, the third rectifying diode D**3** and the fourth switching device SW**4** to cut off an abnormal signal from at least one of the motor driver **106** and motor **109**.

As stated above, the electric bicycle driving apparatus **700** according to the second embodiment of the present invention includes the speed change mode operator **102**, the controller **104**, the motor driver **106**, the relay **708**, and the motor **109**.

Therefore, in the electric bicycle driving apparatus **700** according to the second embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the motor driver **106** for the speed change mode, is supplied to the motor **109**, it may be possible to provide a faster switching response characteristic for a turn-on operation, thereby rapidly reducing a speed change mode time.

Further, in the electric bicycle driving apparatus **700** according to the second embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the motor driver **106** for the speed change mode, is supplied to the motor **109**, it may be possible to reduce heat generation to prevent malfunction.

Moreover, in the electric bicycle driving apparatus **700** according to the second embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the motor driver **106** for the speed change mode, is supplied to the motor **109**, the load to be driven is reduced, thereby reducing consumption of battery power.

In addition, in the electric bicycle driving apparatus **700** according to the second embodiment of the present invention, the first relay **708***a* and the second relay **708***b* are employed. Therefore, when the first motor driving signal or second motor driving signal, output from the motor driver **106** for the speed change mode, is supplied to the motor **109**, each of the first relay **708***a* and second relay **708***b* may provide a faster switching response characteristic for a turn-on operation, thereby more rapidly reducing a speed change mode time.

<Third Embodiment>

FIG. **14** is a block diagram showing the configuration of an electric bicycle driving apparatus according to a third embodiment of the present invention, FIG. **15** is a view showing an embodiment of a relay in FIG. **14**, and FIG. **16** is a view showing another embodiment of the relay in FIG. **14**.

FIG. **17** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **16**, and FIG. **18** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **16**.

Referring to FIGS. **14** to **18**, the electric bicycle driving apparatus according to the third embodiment of the present invention, denoted by reference numeral **1400**, includes a speed change mode operator **102**, a controller **1404**, a first motor driver **1407**, a second motor driver **1406**, a relay **1408**, and a motor **109**.

The speed change mode operator **102** is provided to output a first speed change mode signal or a second speed change mode signal.

The speed change mode operator **102** may be provided at a portion of a handlebar of the electric bicycle **10**.

The controller **1404** receives the first speed change mode signal or second speed change mode signal output from the speed change mode operator **102** and outputs a first control signal corresponding to the first speed change mode signal or a second control signal corresponding to the second speed change mode signal.

The controller **1404** may include an electronic controller unit (ECU) or a micro controller unit (MCU).

When the speed change mode operator **102** outputs a low-speed mode signal corresponding to the first speed change mode signal, the first motor driver **1407** receives the first control signal and outputs a first motor driving signal to drive the motor **109** in a low-speed mode corresponding to a first speed change mode. Also, when the speed change mode operator **102** outputs a high-speed mode signal corresponding to the second speed change mode signal, the second motor driver **1406** receives the second control signal and outputs a second motor driving signal to drive the motor **109**, which is rotating with a driving force of the first motor driving signal, in a high-speed mode corresponding to a second speed change mode.

On the other hand, when the speed change mode operator **102** outputs the high-speed mode signal corresponding to the first speed change mode signal, the second motor driver **1406** receives the first control signal and outputs the first motor driving signal to drive the motor **109** in the high-speed mode corresponding to the first speed change mode. Also, when the speed change mode operator **102** outputs the low-speed mode signal corresponding to the second speed change mode signal, the first motor driver **1407** receives the second control signal and outputs the second motor driving signal to drive the motor **109**, which is rotating with the driving force of the first motor driving signal, in the low-speed mode corresponding to the second speed change mode.

The relay **1408** selectively receives a relay switching enable signal from the controller **1404** so as to be turned on in response to the relay switching enable signal. Upon being turned on, the relay **1408** provides at least one of the first motor driving signal and second motor driving signal to the motor **109**.

As shown in FIGS. **14** to **18**, the relay **1408** may be electrically connected between an output stage of the second motor driver **1406** and an input stage of the motor **109**.

The relay **1408** has an internal circuit **1408***a*, which may include a first rectifying diode D**1**, a first switching device SW**1**, a first resistor R**1**, a second rectifying diode D**2**, a second switching device SW**2**, and a second resistor R**2**, as shown in FIGS. **16** and **17**.

The first rectifying diode D**1** may be electrically connected with one side of the controller **1404**, and the first switching device SW**1** may be electrically connected with the first rectifying diode D**1** and the second motor driver **1406**.

Here, the first switching device SW**1** may include at least one of a metal-oxide semiconductor field effect transistor (MOSFET) and a bipolar junction transistor (BJT).

In this case, the first switching device SW**1** may further include at least one Zener diode ZD**5** which is electrically connected with the first resistor R**1**, and the second switching device SW**2** to be described later, to cut off an abnormal signal from the motor **109**.

The first resistor R**1** may be electrically connected with the first rectifying diode D**1**, the first switching device SW**1** and the second motor driver **1406**, and the second rectifying diode D**2** may be electrically connected with the other side of the controller **1404**.

The second switching device SW**2** may be electrically connected with the second rectifying diode D**2**, the first switching device SW**1** and the motor **109**, and the second resistor R2 may be electrically connected with the second rectifying diode D2, the second switching device SW2 and the motor **109**.

Here, the second switching device SW2 may include at least one of a MOSFET and a BJT.

In this case, the second switching device SW2 may further include at least one Zener diode ZD6 which is electrically connected with the first switching device SW1 and the second resistor R2 to cut off an abnormal signal from the second motor driver **1406**.

In the relay **1408** with the above configuration, when the first and second switching devices SW1 and SW2 are turned on in response to the relay switching enable signal from the controller **1404**, rectified through the first and second rectifying diodes D1 and D2, the level of the first motor driving signal or second motor driving signal supplied from the second motor driver **1406** is adjusted by the first resistor R1 and in turn by the second resistor R2, and the first motor driving signal or second motor driving signal of the adjusted level is then supplied to the motor **109**.

Also, the internal circuit **1408***a* of the relay **1408** may further include one or more Zener diodes ZD1 and ZD2 which are electrically connected with the second motor driver **1406** and the first resistor R1 to cut off an abnormal signal from the second motor driver **1406**.

Also, the internal circuit **1408***a* of the relay **1408** may further include one or more Zener diodes ZD3 and ZD4 which are electrically connected with the second resistor R2 and the motor **109** to cut off an abnormal signal from the motor **109**.

Alternatively, as shown in FIGS. **16** and **18**, the internal circuit **1408***a* of the relay **1408** may include a third rectifying diode D3, a third switching device SW3, a third resistor R3, and a fourth switching device SW4.

The third rectifying diode D3 may be electrically connected with one side of the controller **1404**, and the third switching device SW3 may be electrically connected with the third rectifying diode D3 and the second motor driver **1406**.

Here, the third switching device SW3 may include at least one of a MOSFET and a BJT.

In this case, the third switching device SW3 may further include at least one Zener diode ZD9 which is electrically connected with the second motor driver **1406** and the third resistor R3 to cut off an abnormal signal from the motor **109**.

The third resistor R3 may be electrically connected with the third rectifying diode D3 and the third switching device SW3, and the fourth switching device SW4 may be electrically connected with the third rectifying diode D3, the third resistor R3 and the motor **109**.

Here, the fourth switching device SW4 may include at least one of a MOSFET and a BJT.

In this case, the fourth switching device SW4 may further include at least one Zener diode ZD10 which is electrically connected with the third resistor R3 and the motor **109** to cut off an abnormal signal from the second motor driver **1406**.

Also, the internal circuit **1408***a* of the relay **1408** may further include one or more Zener diodes ZD7 and ZD8 which are electrically connected with the third resistor R3, the third rectifying diode D3 and the fourth switching device SW4 to cut off an abnormal signal from at least one of the second motor driver **1406** and motor **109**.

As stated above, the electric bicycle driving apparatus **1400** according to the third embodiment of the present invention includes the speed change mode operator **102**, the controller **1404**, the first motor driver **1407**, the second motor driver **1406**, the relay **1408**, and the motor **109**.

Therefore, in the electric bicycle driving apparatus **1400** according to the third embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the first motor driver **1407** or second motor driver **1406** for the speed change mode, is supplied to the motor **109**, it may be possible to provide a faster switching response characteristic for a turn-on operation, thereby rapidly reducing a speed change mode time.

Further, in the electric bicycle driving apparatus **1400** according to the third embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the first motor driver **1407** or second motor driver **1406** for the speed change mode, is supplied to the motor **109**, it may be possible to reduce heat generation to prevent malfunction.

Moreover, in the electric bicycle driving apparatus **1400** according to the third embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the first motor driver **1407** or second motor driver **1406** for the speed change mode, is supplied to the motor **109**, the load to be driven is reduced still further, thereby reducing consumption of battery power still further.

In addition, in the electric bicycle driving apparatus **1400** according to the third embodiment of the present invention, the unified relay **1408** is employed, thereby making it possible to suppress an increase in cost of parts manufactured for the speed change mode.

<Fourth Embodiment>

FIG. **19** is a block diagram showing the configuration of an electric bicycle driving apparatus according to a fourth embodiment of the present invention, FIG. **20** is a view showing an embodiment of a relay in FIG. **19**, and FIG. **21** is a view showing another embodiment of the relay in FIG. **19**.

FIG. **22** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **21**, and FIG. **23** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **21**.

Referring to FIGS. **19** to **23**, the electric bicycle driving apparatus according to the fourth embodiment of the present invention, denoted by reference numeral **1900**, includes a speed change mode operator **102**, a controller **1904**, a first motor driver **1907**, a second motor driver **1906**, a relay **1908**, and a motor **109**.

The speed change mode operator **102** is provided to output a first speed change mode signal or a second speed change mode signal.

The speed change mode operator **102** may be provided at a portion of a handlebar of the electric bicycle **10**.

The controller **1904** receives the first speed change mode signal or second speed change mode signal output from the speed change mode operator **102** and outputs a first control signal corresponding to the first speed change mode signal or a second control signal corresponding to the second speed change mode signal.

The controller **1904** may include an electronic controller unit (ECU) or a micro controller unit (MCU).

When the speed change mode operator **102** outputs a low-speed mode signal corresponding to the first speed change mode signal, the first motor driver **1907** receives the first control signal and outputs a first motor driving signal to drive the motor **109** in a low-speed mode corresponding to a first speed change mode. Also, when the speed change mode operator **102** outputs a high-speed mode signal corresponding to the second speed change mode signal, the second motor driver **1906** receives the second control signal and outputs a second motor driving signal to drive the motor **109**, which is rotating with a driving force of the first motor driving signal, in a high-speed mode corresponding to a second speed change mode.

On the other hand, when the speed change mode operator **102** outputs the high-speed mode signal corresponding to the first speed change mode signal, the second motor driver **1906** receives the first control signal and outputs the first motor driving signal to drive the motor **109** in the high-speed mode corresponding to the first speed change mode. Also, when the speed change mode operator **102** outputs the low-speed mode signal corresponding to the second speed change mode signal, the first motor driver **1907** receives the second control signal and outputs the second motor driving signal to drive the motor **109**, which is rotating with the driving force of the first motor driving signal, in the low-speed mode corresponding to the second speed change mode.

The relay **1908** selectively receives a relay switching enable signal from the controller **1904** so as to be turned on in response to the relay switching enable signal. Upon being turned on, the relay **1908** provides at least one of the first motor driving signal and second motor driving signal to the motor **109**.

As shown in FIGS. **19** to **23**, the relay **1908** may be electrically connected between an output stage of the first motor driver **1907** and an input stage of the motor **109**.

The relay **1908** has an internal circuit **1908***a*, which may include a first rectifying diode D**1**, a first switching device SW**1**, a first resistor R**1**, a second rectifying diode D**2**, a second switching device SW**2**, and a second resistor R**2**, as shown in FIGS. **21** and **22**.

The first rectifying diode D**1** may be electrically connected with one side of the controller **1904**, and the first switching device SW**1** may be electrically connected with the first rectifying diode D**1** and the first motor driver **1907**.

Here, the first switching device SW**1** may include at least one of a metal-oxide semiconductor field effect transistor (MOSFET) and a bipolar junction transistor (BJT).

In this case, the first switching device SW**1** may further include at least one Zener diode ZD**5** which is electrically connected with the first resistor R**1**, and the second switching device SW**2** to be described later, to cut off an abnormal signal from the motor **109**.

The first resistor R**1** may be electrically connected with the first rectifying diode D**1**, the first switching device SW**1** and the first motor driver **1907**, and the second rectifying diode D**2** may be electrically connected with the other side of the controller **1904**.

The second switching device SW**2** may be electrically connected with the second rectifying diode D**2**, the first switching device SW**1** and the motor **109**, and the second resistor R**2** may be electrically connected with the second rectifying diode D**2**, the second switching device SW**2** and the motor **109**.

Here, the second switching device SW**2** may include at least one of a MOSFET and a BJT.

In this case, the second switching device SW**2** may further include at least one Zener diode ZD**6** which is electrically connected with the first switching device SW**1** and the second resistor R**2** to cut off an abnormal signal from the first motor driver **1907**.

In the relay **1908** with the above configuration, when the first and second switching devices SW**1** and SW**2** are turned on in response to the relay switching enable signal from the controller **1904**, rectified through the first and second rectifying diodes D**1** and D**2**, the level of the first motor driving signal or second motor driving signal supplied from the first motor driver **1907** is adjusted by the first resistor R**1** and in turn by the second resistor R**2**, and the first motor driving signal or second motor driving signal of the adjusted level is then supplied to the motor **109**.

Also, the internal circuit **1908***a* of the relay **1908** may further include one or more Zener diodes ZD**1** and ZD**2** which are electrically connected with the first motor driver **1907** and the first resistor R**1** to cut off an abnormal signal from the first motor driver **1907**.

Also, the internal circuit **1908***a* of the relay **1908** may further include one or more Zener diodes ZD**3** and ZD**4** which are electrically connected with the second resistor R**2** and the motor **109** to cut off an abnormal signal from the motor **109**.

Alternatively, as shown in FIGS. **21** and **23**, the internal circuit **1908***a* of the relay **1908** may include a third rectifying diode D**3**, a third switching device SW**3**, a third resistor R**3**, and a fourth switching device SW**4**.

The third rectifying diode D**3** may be electrically connected with one side of the controller **1904**, and the third switching device SW**3** may be electrically connected with the third rectifying diode D**3** and the first motor driver **1907**.

Here, the third switching device SW**3** may include at least one of a MOSFET and a BJT.

In this case, the third switching device SW**3** may further include at least one Zener diode ZD**9** which is electrically connected with the first motor driver **1907** and the third resistor R**3** to cut off an abnormal signal from the motor **109**.

The third resistor R**3** may be electrically connected with the third rectifying diode D**3** and the third switching device SW**3**, and the fourth switching device SW**4** may be electrically connected with the third rectifying diode D**3**, the third resistor R**3** and the motor **109**.

Here, the fourth switching device SW**4** may include at least one of a MOSFET and a BJT.

In this case, the fourth switching device SW**4** may further include at least one Zener diode ZD**10** which is electrically connected with the third resistor R**3** and the motor **109** to cut off an abnormal signal from the first motor driver **1907**.

Also, the internal circuit **1908***a* of the relay **1908** may further include one or more Zener diodes ZD**7** and ZD**8** which are electrically connected with the third resistor R**3**, the third rectifying diode D**3** and the fourth switching device SW**4** to cut off an abnormal signal from at least one of the first motor driver **1907** and motor **109**.

As stated above, the electric bicycle driving apparatus **1900** according to the fourth embodiment of the present invention includes the speed change mode operator **102**, the controller **1904**, the first motor driver **1907**, the second motor driver **1906**, the relay **1908**, and the motor **109**.

Therefore, in the electric bicycle driving apparatus **1900** according to the fourth embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the first motor driver **1907** or second motor driver **1906** for the speed change mode, is supplied to the motor **109**, it may be possible to provide a faster switching response characteristic for a turn-on operation, thereby rapidly reducing a speed change mode time.

Further, in the electric bicycle driving apparatus **1900** according to the fourth embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the first motor driver **1907** or second motor driver **1906** for the speed change mode, is supplied to the motor **109**, it may be possible to reduce heat generation to prevent malfunction.

Moreover, in the electric bicycle driving apparatus **1900** according to the fourth embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the first motor driver **1907** or second motor driver **1906** for the speed change mode, is supplied to the motor **109**, the load to be driven is reduced still further, thereby reducing consumption of battery power still further.

In addition, in the electric bicycle driving apparatus **1900** according to the fourth embodiment of the present invention, the unified relay **1908** is employed, thereby making it possible to suppress an increase in cost of parts manufactured for the speed change mode.

<Fifth Embodiment>

FIG. **24** is a block diagram showing the configuration of an electric bicycle driving apparatus according to a fifth embodiment of the present invention, FIG. **25** is a view showing an embodiment of a relay connected to a second motor driver, shown in FIG. **24**, and FIG. **26** is a view showing another embodiment of the relay connected to the second motor driver, shown in FIG. **24**.

FIG. **27** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **26**, and FIG. **28** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **26**.

FIG. **29** is a view showing an embodiment of a relay connected to a first motor driver, shown in FIG. **24**, and FIG. **30** is a view showing another embodiment of the relay connected to the first motor driver, shown in FIG. **24**.

FIG. **31** is an equivalent circuit diagram showing an example of an internal configuration of the relay shown in FIG. **30**, and FIG. **32** is an equivalent circuit diagram showing another example of the internal configuration of the relay shown in FIG. **30**.

Referring to FIGS. **24** to **32**, the electric bicycle driving apparatus according to the fifth embodiment of the present invention, denoted by reference numeral **2400**, includes a speed change mode operator **102**, a controller **2404**, a first motor driver **2407**, a second motor driver **2406**, first and second relays **2409** and **2408**, and a motor **109**.

The speed change mode operator **102** is provided to output a first speed change mode signal or a second speed change mode signal.

The speed change mode operator **102** may be provided at a portion of a handlebar of the electric bicycle **10**.

The controller **2404** receives the first speed change mode signal or second speed change mode signal output from the speed change mode operator **102** and outputs a first control signal corresponding to the first speed change mode signal or a second control signal corresponding to the second speed change mode signal.

The controller **2404** may include an electronic controller unit (ECU) or a micro controller unit (MCU).

When the speed change mode operator **102** outputs a low-speed mode signal corresponding to the first speed change mode signal, the first motor driver **2407** receives the first control signal and outputs a first motor driving signal to drive the motor **109** in a low-speed mode corresponding to a first speed change mode. Also, when the speed change mode operator **102** outputs a high-speed mode signal corresponding to the second speed change mode signal, the second motor driver **2406** receives the second control signal and outputs a second motor driving signal to drive the motor **109**, which is rotating with a driving force of the first motor driving signal, in a high-speed mode corresponding to a second speed change mode.

On the other hand, when the speed change mode operator **102** outputs the high-speed mode signal corresponding to the first speed change mode signal, the second motor driver **2406** receives the first control signal and outputs the first motor driving signal to drive the motor **109** in the high-speed mode corresponding to the first speed change mode. Also, when the speed change mode operator **102** outputs the low-speed mode signal corresponding to the second speed change mode signal, the first motor driver **2407** receives the second control signal and outputs the second motor driving signal to drive the motor **109**, which is rotating with the driving force of the first motor driving signal, in the low-speed mode corresponding to the second speed change mode.

The first and second relays **2409** and **2408** selectively receive a relay switching enable signal from the controller **2404** so as to be turned on in response to the relay switching enable signal. Upon being turned on, the first and second relays **2409** and **2408** provide the first motor driving signal and the second motor driving signal to the motor **109**.

As shown in FIGS. **24** to **32**, the first relay **2409** provides the first motor driving signal output from the first motor driver **2407** to the motor **109**, and the second relay **2408** provides the second motor driving signal output from the second motor driver **2406** to the motor **109**.

The second relay **2408** may be electrically connected between an output stage of the second motor driver **2406** and an input stage of the motor **109**.

As shown in FIG. **26** or **27**, the second relay **2408** selectively receives a second relay switching enable signal of the relay switching enable signal so as to be turned on in response to the second relay switching enable signal. Upon being turned on, the second relay **2408** supplies the second motor driving signal to the motor **109**.

The second relay **2408** has an internal circuit **2408***a*, which may include a first rectifying diode D**1**, a first switching device SW**1**, a first resistor R**1**, a second rectifying diode D**2**, a second switching device SW**2**, and a second resistor R**2**.

The first rectifying diode D**1** may be electrically connected with one side of the controller **2404**, and the first switching device SW**1** may be electrically connected with the first rectifying diode D**1** and the second motor driver **2406**.

Here, the first switching device SW**1** may include at least one of a metal-oxide semiconductor field effect transistor (MOSFET) and a bipolar junction transistor (BJT).

In this case, the first switching device SW**1** may further include at least one Zener diode ZD**5** which is electrically connected with the first resistor R**1**, and the second switching device SW**2** to be described later, to cut off an abnormal signal from the motor **109**.

The first resistor R**1** may be electrically connected with the first rectifying diode D**1**, the first switching device SW**1** and the second motor driver **2406**, and the second rectifying diode D**2** may be electrically connected with the other side of the controller **2404**.

The second switching device SW**2** may be electrically connected with the second rectifying diode D**2**, the first switching device SW**1** and the motor **109**, and the second resistor R**2** may be electrically connected with the second rectifying diode D**2**, the second switching device SW**2** and the motor **109**.

Here, the second switching device SW**2** may include at least one of a MOSFET and a BJT.

In this case, the second switching device SW**2** may further include at least one Zener diode ZD**6** which is electrically connected with the first switching device SW**1** and the second resistor R**2** to cut off an abnormal signal from the second motor driver **2406**.

In the second relay **2408** with the above configuration, when the first and second switching devices SW**1** and SW**2** are turned on in response to the relay switching enable signal from the controller **2404**, rectified through the first and second rectifying diodes D**1** and D**2**, the level of the first motor driving signal or second motor driving signal supplied from the second motor driver **2406** is adjusted by the first resistor R**1** and in turn by the second resistor R**2**, and the first motor driving signal or second motor driving signal of the adjusted level is then supplied to the motor **109**.

Also, the internal circuit **2408***a* of the second relay **2408** may further include one or more Zener diodes ZD**1** and ZD**2** which are electrically connected with the second motor driver **2406** and the first resistor R**1** to cut off an abnormal signal from the second motor driver **2406**.

Also, the internal circuit **2408***a* of the second relay **2408** may further include one or more Zener diodes ZD**3** and ZD**4** which are electrically connected with the second resistor R**2** and the motor **109** to cut off an abnormal signal from the motor **109**.

Alternatively, as shown in FIG. **26** or **28**, the second relay **2408** selectively receives the second relay switching enable signal of the relay switching enable signal so as to be turned on in response to the second relay switching enable signal. Upon being turned on, the second relay **2408** supplies the second motor driving signal to the motor **109**.

The internal circuit **2408***a* of the second relay **2408** may include a third rectifying diode D**3**, a third switching device SW**3**, a third resistor R**3**, and a fourth switching device SW**4**.

The third rectifying diode D**3** may be electrically connected with one side of the controller **2404**, and the third switching device SW**3** may be electrically connected with the third rectifying diode D**3** and the second motor driver **2406**.

Here, the third switching device SW**3** may include at least one of a MOSFET and a BJT.

In this case, the third switching device SW**3** may further include at least one Zener diode ZD**9** which is electrically connected with the second motor driver **2406** and the third resistor R**3** to cut off an abnormal signal from the motor **109**.

The third resistor R**3** may be electrically connected with the third rectifying diode D**3** and the third switching device SW**3**, and the fourth switching device SW**4** may be electrically connected with the third rectifying diode D**3**, the third resistor R**3** and the motor **109**.

Here, the fourth switching device SW**4** may include at least one of a MOSFET and a BJT.

In this case, the fourth switching device SW**4** may further include at least one Zener diode ZD**10** which is electrically connected with the third resistor R**3** and the motor **109** to cut off an abnormal signal from the second motor driver **2406**.

Also, the internal circuit **2408***a* of the second relay **2408** may further include one or more Zener diodes ZD**7** and ZD**8** which are electrically connected with the third resistor R**3**, the third rectifying diode D**3** and the fourth switching device SW**4** to cut off an abnormal signal from at least one of the second motor driver **2406** and motor **109**.

On the other hand, the first relay **2409** may be electrically connected between an output stage of the first motor driver **2407** and the input stage of the motor **109**, as shown in FIGS. **29** to **32**.

As shown in FIG. **30** or **31**, the first relay **2409** selectively receives a first relay switching enable signal of the relay switching enable signal so as to be turned on in response to the first relay switching enable signal. Upon being turned on, the first relay **2409** supplies the first motor driving signal to the motor **109**.

The first relay **2409** has an internal circuit **2409***a*, which may include a first rectifying diode D**1**, a first switching device SW**1**, a first resistor R**1**, a second rectifying diode D**2**, a second switching device SW**2**, and a second resistor R**2**.

The first rectifying diode D**1** may be electrically connected with one side of the controller **2404**, and the first switching device SW**1** may be electrically connected with the first rectifying diode D**1** and the first motor driver **2407**.

Here, the first switching device SW**1** may include at least one of a metal-oxide semiconductor field effect transistor (MOSFET) and a bipolar junction transistor (BJT).

In this case, the first switching device SW**1** may further include at least one Zener diode ZD**5** which is electrically connected with the first resistor R**1**, and the second switching device SW**2** to be described later, to cut off an abnormal signal from the motor **109**.

The first resistor R**1** may be electrically connected with the first rectifying diode D**1**, the first switching device SW**1** and the first motor driver **2407**, and the second rectifying diode D**2** may be electrically connected with the other side of the controller **2404**.

The second switching device SW**2** may be electrically connected with the second rectifying diode D**2**, the first switching device SW**1** and the motor **109**, and the second resistor R**2** may be electrically connected with the second rectifying diode D**2**, the second switching device SW**2** and the motor **109**.

Here, the second switching device SW**2** may include at least one of a MOSFET and a BJT.

In this case, the second switching device SW**2** may further include at least one Zener diode ZD**6** which is electrically connected with the first switching device SW**1** and the second resistor R**2** to cut off an abnormal signal from the first motor driver **2407**.

In the first relay **2409** with the above configuration, when the first and second switching devices SW**1** and SW**2** are turned on in response to the relay switching enable signal from the controller **2404**, rectified through the first and second rectifying diodes D**1** and D**2**, the level of the first motor driving signal or first motor driving signal supplied from the first motor driver **2407** is adjusted by the first resistor R**1** and in turn by the second resistor R**2**, and the first motor driving signal or first motor driving signal of the adjusted level is then supplied to the motor **109**.

Also, the internal circuit **2409***a* of the first relay **2409** may further include one or more Zener diodes ZD**1** and ZD**2** which are electrically connected with the first motor driver **2407** and the first resistor R**1** to cut off an abnormal signal from the first motor driver **2407**.

Also, the internal circuit **2409***a* of the first relay **2409** may further include one or more Zener diodes ZD**3** and ZD**4** which are electrically connected with the second resistor R**2** and the motor **109** to cut off an abnormal signal from the motor **109**.

Alternatively, as shown in FIG. **30** or **32**, the first relay **2409** selectively receives the first relay switching enable signal of the relay switching enable signal so as to be turned on in response to the first relay switching enable signal. Upon being turned on, the first relay **2409** supplies the first motor driving signal to the motor **109**.

The internal circuit **2409***a* of the first relay **2409** may include a third rectifying diode D**3**, a third switching device SW**3**, a third resistor R**3**, and a fourth switching device SW**4**.

The third rectifying diode D**3** may be electrically connected with one side of the controller **2404**, and the third switching device SW**3** may be electrically connected with the third rectifying diode D**3** and the first motor driver **2407**.

Here, the third switching device SW**3** may include at least one of a MOSFET and a BJT.

In this case, the third switching device SW**3** may further include at least one Zener diode ZD**9** which is electrically connected with the first motor driver **2407** and the third resistor R**3** to cut off an abnormal signal from the motor **109**.

The third resistor R**3** may be electrically connected with the third rectifying diode D**3** and the third switching device SW**3**, and the fourth switching device SW**4** may be electrically connected with the third rectifying diode D**3**, the third resistor R**3** and the motor **109**.

Here, the fourth switching device SW**4** may include at least one of a MOSFET and a BJT.

In this case, the fourth switching device SW**4** may further include at least one Zener diode ZD**10** which is electrically connected with the third resistor R**3** and the motor **109** to cut off an abnormal signal from the first motor driver **2407**.

Also, the internal circuit **2409***a* of the first relay **2409** may further include one or more Zener diodes ZD**7** and ZD**8** which are electrically connected with the third resistor R**3**, the third rectifying diode D**3** and the fourth switching device SW**4** to cut off an abnormal signal from at least one of the first motor driver **2407** and motor **109**.

As stated above, the electric bicycle driving apparatus **2400** according to the fifth embodiment of the present invention includes the speed change mode operator **102**, the controller **2404**, the first motor driver **2407**, the second motor driver **2406**, the first relay **2409**, the second relay **2408**, and the motor **109**.

Therefore, in the electric bicycle driving apparatus **2400** according to the fifth embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the first motor driver **2407** or second motor driver **2406** for the speed change mode, is supplied to the motor **109**, it may be possible to provide a faster switching response characteristic for a turn-on operation, thereby rapidly reducing a speed change mode time.

Further, in the electric bicycle driving apparatus **2400** according to the fifth embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the first motor driver **2407** or second motor driver **2406** for the speed change mode, is supplied to the motor **109**, it may be possible to reduce heat generation to prevent malfunction.

Moreover, in the electric bicycle driving apparatus **2400** according to the fifth embodiment of the present invention, when the first motor driving signal or second motor driving signal, output from the first motor driver **2407** or second motor driver **2406** for the speed change mode, is supplied to the motor **109**, the load to be driven is reduced, thereby reducing consumption of battery power.

In addition, in the electric bicycle driving apparatus **2400** according to the fifth embodiment of the present invention, the first relay **2409** and the second relay **2408** are employed. Therefore, when the first motor driving signal or second motor driving signal, output from the first motor driver **2407** or second motor driver **2406** for the speed change mode, is supplied to the motor **109**, each of the first relay **2409** and second relay **2408** may provide a faster switching response characteristic for a turn-on operation, thereby more rapidly reducing a speed change mode time.

Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

**1**. An electric bicycle driving apparatus comprising:

a speed change mode operator to selectively output one of a first speed change mode signal and a second speed change mode signal;



a controller to receive the first speed change mode signal or second speed change mode signal output from the speed change mode operator and output a first control signal corresponding to the first speed change mode signal or a second control signal corresponding to the second speed change mode signal;

a motor driver to, when the speed change mode operator outputs the first speed change mode signal, receive the first control signal and output a first motor driving signal to drive a motor in a first speed change mode, and, when the speed change mode operator outputs the second speed change mode signal, receive the second control signal and output a second motor driving signal to drive the motor, the motor rotating with a driving force of the first motor driving signal, in a second speed change mode; and

a relay to selectively receive a relay switching enable signal from the controller, the relay being turned on in response to the relay switching enable signal to provide at least one of the first motor driving signal and second motor driving signal to the motor,

wherein the relay further includes at least one Zener Diode to cut off an abnormal signal from at least one of the motor driver and the motor.

**2**. The electric bicycle driving apparatus according to claim **1**, wherein:

the first speed change mode signal is a low-speed mode signal, and the first speed change mode is a low-speed mode; and

the second speed change mode signal is a high-speed mode signal, and the second speed change mode is a high-speed mode.

**3**. The electric bicycle driving apparatus according to claim **1**, wherein:

the first speed change mode signal is a high-speed mode signal, and the first speed change mode is a high-speed mode; and

the second speed change mode signal is a low-speed mode signal, and the second speed change mode is a low-speed mode.

**4**. The electric bicycle driving apparatus according to claim **1**, wherein the relay is electrically connected between an output stage of the motor driver and an input stage of the motor.

**5**. The electric bicycle driving apparatus according to claim **1**, wherein the relay comprises:

a first relay to provide the first motor driving signal output from the motor driver to the motor: and

a second relay to provide the second motor driving signal output from he motor driver to the motor,

wherein the first relay and the second relay are electrically connected between an output stage of the motor driver and an input stage of the motor.

**6**. The electric bicycle driving apparatus according to claim **1**, wherein the motor driver comprises:

a first motor driver to output the first motor driving signal; and

a second motor driver to output the second motor driving signal,

wherein the relay is electrically connected between at least one of output stages of the first motor driver and second motor driver and an input stage of the motor.

**7**. The electric bicycle driving apparatus according to claim **1**, wherein:

the motor driver comprises:

a first motor driver to output the first motor driving signal; and a second motor driver to output the second motor driving signal; and

the relay comprises a first relay and a second relay,

wherein the first relay is electrically connected between an output stage of the first motor driver and an input stage of the motor, and

wherein the second relay is electrically connected between an output stage of the second motor driver and the input stage of the motor.

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